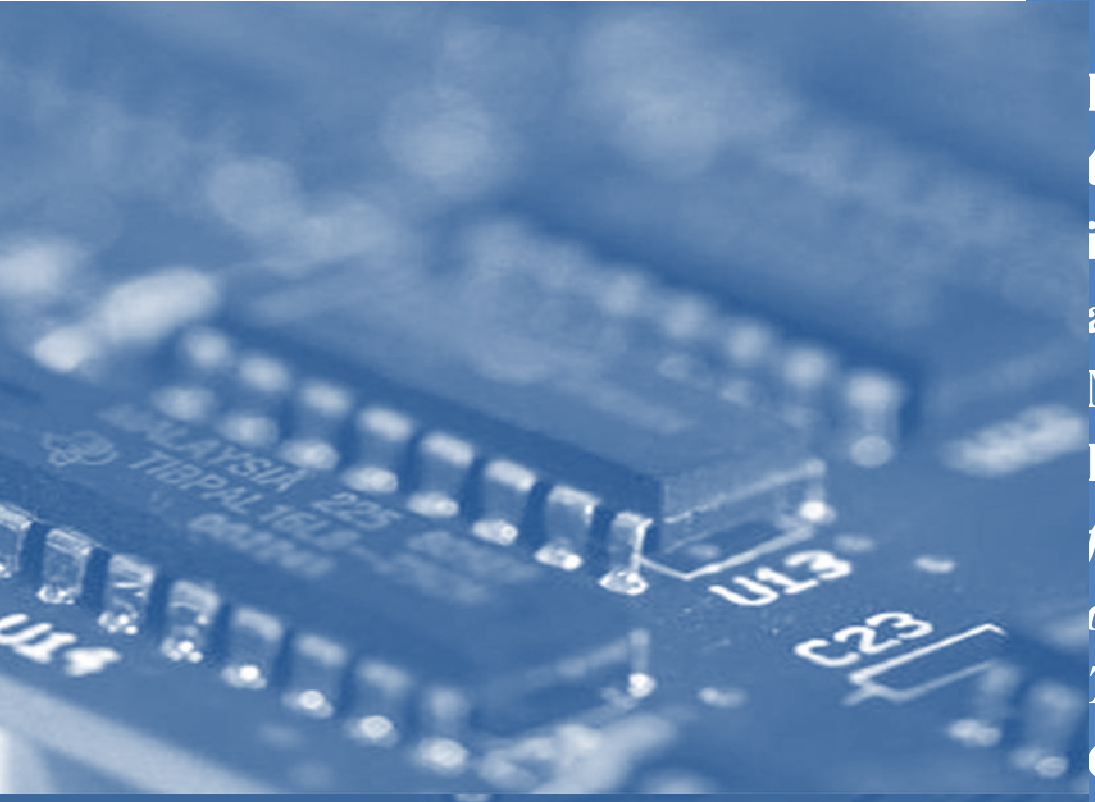

Report on mapping the manpower skills in the IT Hardware and Electronics Manufacturing Industry – *a study for the Department of Information Technology, Government of India*

Manufacturers' Association for Information Technology

MAIT Manufacturers' Association for Information Technology

September, 2008

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1. Background of the study

The Department of Information Technology, in consultation with the National Manufacturing Competitiveness Council (NMCC), entrusted the Manufacturers' Association for Information Technology (MAIT) to assess the manpower and skill requirement in the IT Hardware and Electronics Manufacturing Industry, with a view to take necessary steps to meet the future manpower requirements of the industry.

MAIT has carried out the study across the major production clusters in several sectors, namely, consumer electronics, IT related hardware, components, strategic electronics, and telecom equipment. The study involved interactions with industry associations, companies, educational institutes and research institutes involved with the IT Hardware and Electronics Manufacturing Industry. This report details our findings and recommendations.

1.1 Scope of Work

The scope of work is to '*undertake a study on mapping of human resources skills for the electronics manufacturing industry in India*'. This has been performed for both manufacturing and service professionals with respect to the following industries:

- Consumer Electronics
- IT related hardware
- Components (both active and passive component manufacturers)
- Strategic Electronics (defence establishments)
- Telecom equipment.

1.2 Objectives of the project

The objectives of this project are as follows:

1. Estimate the manpower requirement to support the growth of each of the industry sectors for both manufacturers and ancillaries – at present (2008) and by 2015
2. Identify industry trends that would impact the future manpower requirement
3. Map current and future skill requirements to support the industry growth
4. Identify gaps in skill requirement among the personnel working in the industry at various levels
5. Evaluate the capability of educational institutes to provide skilled manpower to support the industry's growth

6. Suggest suitable recommendations on interventions to be taken by stakeholders to address the manpower skill related issues facing the industry
7. Suggest broad course structure and content that should be adopted at various levels of educational institutions.

1.3 Production clusters covered as part of this study

The production clusters covered as part of this study for an understanding of skill gaps issues and interventions required for growth of IT Hardware and Electronics Manufacturing sector include:

- Chennai – Pondicherry
- Bengaluru – Hosur
- Hyderabad
- Mumbai – Navi Mumbai
- Pune – Aurangabad – Nashik
- Uttarkhand
- Himachal Pradesh
- NCR (Delhi), Gurgaon, Noida.

1.4 Approach and Methodology

The study has been carried out in five modules as follows:

- ***Module 1: Environment Scanning and Industry Analysis***

In this module, an overview of the macro and micro environment of IT Hardware and Electronics Manufacturing Industry has been provided. The outlook of these sectors in India has also been covered. Among other parameters, the following have been analysed for each of the industries:

- Market size (domestic versus exports and type of products) and growth
- Market structure – major players and competition
- Regulatory framework for the industry
- Future outlook for the industry.

The growth prospects of Indian IT Hardware and Electronics Manufacturing Industry have been reviewed in the light of global scenario, regulatory environment and most importantly availability of skilled manpower.

- ***Module 2: Mapping of current employment pattern***

In this module, MAIT has mapped the current employment pattern in the various sectors of the Indian IT Hardware and Electronics Manufacturing Industry and the proportion of direct employment at various levels of production and support functions. This has been carried out by analysing the historical employment trend in the identified sectors through detailed interactions with leading industry players.

- ***Module – 3: Identifying human resources requirement to support the growth potential***

In this module, the human resources requirement to support the growth potential of the sectors under consideration has been estimated by forecasting key metrics such as revenue per person, potential increases in value addition, productivity improvement and changes in industry structure and business practices.

- ***Module – 4: Mapping current and future skill requirements and the gaps at various levels***

This module encompasses two parts:

Part 1: Mapping current and future skill requirement of identified sectors

Here the current and future skill requirements have been mapped by:

- Reviewing the value chain activities in the various sectors of IT Hardware and Electronics Manufacturing Industry (Consumer Electronics, IT related hardware, components - active and passive components, strategic electronics and telecom equipment)
- Identifying the broad level activities in the sectors – professional, operational and support activities
- Identifying skills required (functional and soft skills) to support these activities in the future as well by looking at key segment growth drivers such as technology changes, business practices, local and international trade policies, Government regulations etc.

The output of this module is the sector-wise skill requirements in the industry.

Part 2: Identification of skill gaps

In this part, we have identified key skill gaps by analysing the demand (requirement from the sectors under consideration) and supply (training institutes) by covering the following:

- Present educational infrastructure available for the industry
- Skill expectations and problems faced by the industry in terms of availability of skilled people
- Current issues in course curriculum
- Current level of employability of students
- Extent of Institute and Industry interactions

- Performance of new recruits as per industry's perception.

- ***Module – 5: Recommendations***

The objective of this module is to propose a set of recommendations to address skill gap issues to various stakeholders, namely, Government, Industry and Educational Institutions. The following presents an illustrative list of the areas our recommendations would cover:

- Government: Our recommendations would focus on
    - Policy level: What kind of policy changes needs to be put in place to drive the skill development initiatives?
    - Infrastructure: What kind of infrastructure needs to be developed to address the bottlenecks? What are the options available to develop the infrastructure?
    - Implementation mechanism: How to implement various skill development programmes? Who is the project owner? What are the constituents of implementation structure?
- Industry: Industry level recommendations focus on setting standards, content feedback and preparation, training the trainees, skill certification, industry participation in skill transfer (practical application).
- Education institutes: Our recommendations focus on broad course content that needs to be introduced, networking, training the trainers.

2. Overview of Indian IT Hardware and Electronics Industry

2.1 Background of the Indian IT Hardware and Electronics Industry

India's IT Hardware and Electronics Manufacturing Industry has grown at 16.2% compounded annually over the past six years with a production estimated to be Rs. 808 billion in 2007-08. There are more than 3,500 electronics manufacturing units and 250,000 small and tiny units directly or indirectly supporting the electronics and electrical manufacturing industry. India's electronics industry represents a miniscule 0.7% of the global electronics industry. The current growth trend and its existing contribution to the global electronics industry indicates that the share of IT Hardware and Electronics Manufacturing Industry in India, in terms of output and employment, has the potential to improve manifolds, driven by its emergence in the global electronics manufacturing value chain.

The seeds of rapid growth of the electronics industry were sown in the 1990s with the advent of economic liberalisation and the industry has exhibited significant growth ever since. The electronics sector has been de-licensed except for aerospace and defence electronics. Fiscal and trade policies for the electronics sector have been formulated in a way so as to encourage investments in this sector. These include:

- Free import of components, raw materials and capital goods
- Duty free environment for export of electronic hardware under the export oriented schemes
- Necessary infrastructure for uninterrupted power for large scale electronics manufacturers.

Apart from being an attractive investment location for production of IT Hardware and Electronics products, India has also emerged as a mass market for consumer electronics and telecom with the rise in purchasing power of local population. At present, the consumer electronics segment is the largest segment and shows a higher growth than the other segments. The personal computers segment in India is expected to witness a robust growth on account of estimated addition of over 50 million new personal computer users by 2010. The demand for a wide range of new genre digital products such as fuse embedded software, radio frequency identification technologies, voice as well as video signalling devices present an array of opportunities to manufacturers. Telecom is the fastest growing segment with an estimated capital expenditure of USD 50 billion.

2.2 Size and Structure of the IT Hardware and Electronic industry

The Indian IT Hardware and Electronics Industry has touched a production level of Rs.808 billion in 2007-08, up from Rs. 327.5 billion in 2001-02, a compound annual growth rate (CAGR) of 16.2%. The industry

can be structured along key sectors viz. consumer electronics, IT related hardware, components, strategic electronics, telecom equipment, and others (mainly control instrumentation and industrial sector). The following table presents the composition of the Indian IT Hardware and Electronics industry in terms of its various constituents in 2001-02 and in 2007-08 (estimated).

In absolute terms, consumer electronics is the largest sector with a production of Rs. 225 billion, followed by the computers sector at Rs.164 billion.

Table 1: Market size of IT Hardware and Electronics Manufacturing Industry by sector

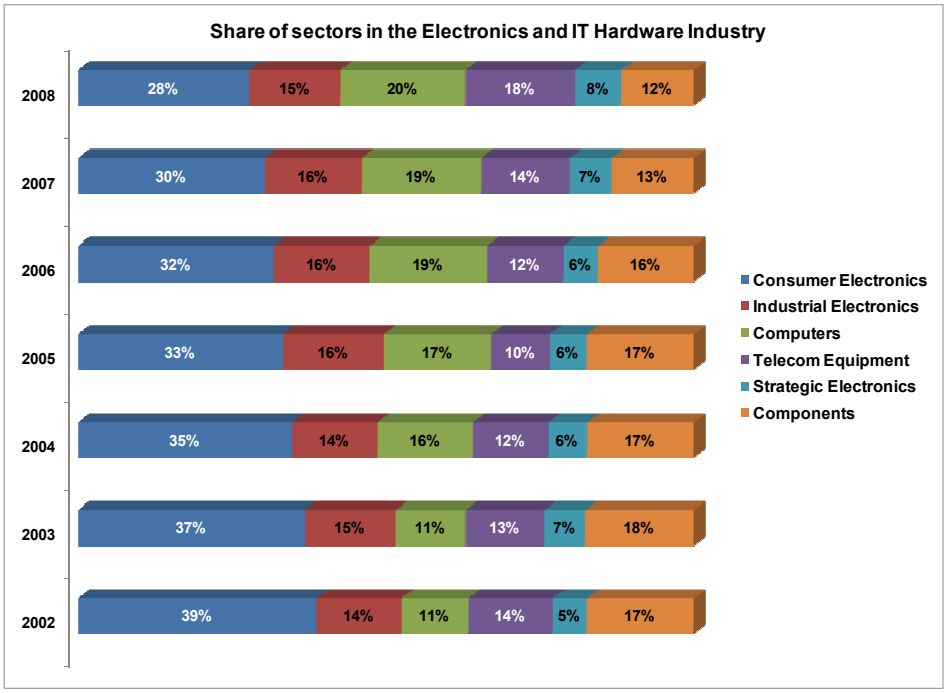
Rs. billion

	2002	2003	2004	2005	2006	2007	2008*	CAGR
Consumer Electronics	127	138	152	168	180	200	225	10.0%
Computers	36	43	68	88	108	128	164	29.1%
Telecom Equipment	45	48	54	48	70	95	144	21.3%
Strategic Electronics	18	25	28	30	32	45	61	22.6%
Components	57	66	76	88	88	88	95	8.9%
Others	45	56	61	83	88	104	120	17.7%
TOTAL	328	375	438	505	566	660	808	16.2%

**Estimated*

Source: Annual Report 2007-08 of Department of Information Technology, Government of India

Figure 1: Share of various sectors in the Indian IT Hardware and Electronics Manufacturing Industry



As can be seen from the production mix, the share of consumer electronics has fallen from 39% to 28% between 2001-02 and 2007-08. Share of components has fallen from 17% to 12% during this period. The computing devices sector has shown a growth in share from 11% in 2001-02 to 20%

in 2007-08. The share of telecom equipment and strategic electronics has also increased in the total production of IT Hardware and Electronics Manufacturing Industry.

Consumer Electronics

Consumer electronics comprises products like televisions, audio and video systems, set top boxes (STB), amongst others. This segment has a large manufacturing base and is fairly cost competitive. Consumer electronics is a major sector and it contributes to roughly 28% of the total IT Hardware and Electronic Industry production in the country, with an estimated turnover of Rs. 225 billion in 2007-08.

The colour television (CTV) segment is the largest contributor to the consumer electronics segment. During the financial year 2007-08, the domestic market of CTV is estimated to cross 15 million units. This includes about 2.5 million sets of 14" CTV supplied to Government of Tamil Nadu for distribution amongst the masses. The growth in the CTV segment has been driven by the growth of direct-to-home (DTH) broadcasting business and rising disposable incomes. The flat segment of CTVs now accounts for more than 50% of the total domestic TV production. The hi-end products, particularly liquid crystal display (LCD) TVs and plasma TV are gaining popularity. The LCD TVs segment continues to grow at more than 100% per annum and is expected to cross 3 million by 2010-11. The phenomenon of falling prices in the LCD segment continues in the market and there is a general tendency for consumers to go in for larger size LCD TVs. The highest selling size in 2006-07 was 32" LCD TV as against 26" in the previous year. It is estimated that in 2007-08, the popular size was 42" LCD TVs. Manufacturing of LCD TVs has started in the country and it is expected that it would increase as the demand rises.

DVD players segment continued to grow and is estimated at over 7 million sets in 2007-08. Investment has taken place in tax exempted regions, mostly by SMEs working for reputed brands. There has been a good growth in the Home Theatre segment. This has also been fuelled by the introduction of DTH by private operators, in the country. There has been exponential growth in the STB market, due to introduction of CAS in the metros and expansion of DTH in the country. About 25-30% of the total requirement of STBs is being met by indigenous sources, the rest is imported.

Production of Black and White TV has continued to decline.

IT related hardware

This segment includes personal computers, servers, workstations, supercomputers, data processing equipment and peripherals such as monitors, keyboards, disk drives, printers, plotters, SMPS, modems,

networking products and add-on cards. The estimated production of this sector in 2007-08 is Rs. 164 billion.

The Desktop PC market (including Notebooks) grossed 3.28 million units in the first half of financial year 2007-08. There was significant growth in notebook sales (roughly 59% over the previous year) with desktops growing at lower rate. PC sales are projected to continue on their growth trajectory given the strong macroeconomic conditions and buoyant buying sentiment in the market, led by demand from various industry verticals. In 2007-08 it is estimated that sales will cross 7.25 million units. The high growth in PC sales may be attributed to increased consumption by industry verticals such as telecom, banking and financial services, manufacturing, education, retail and BPO/IT-enabled services as well as major e-governance initiatives of the central and state Governments. Further, significant consumption in the small and medium enterprises contributed to the industry growth and consumption in the home market remained buoyant. This has been accompanied by a southward trend in prices year after year due to technology reasons.

Till recently, this segment was dominated by local assemblers and some branded Indian companies. A number of MNCs (such as Compaq, HP, IBM, and ACER) are now assembling PCs locally and have started focusing on satellite towns and cities for sales. Wipro and Zenith are the domestic market leaders.

Telecommunication equipment

The telecommunication equipment segment includes digital exchanges (EPABX, RAX, TAX and MAX), transmission equipment (HF/VHF/Microwave trans-receivers), satellite communication terminals, optical fibre communication equipment, two-way radio communication equipment. The estimated production of this sector in 2007-08 is Rs. 143.5 billion.

Communication technology has taken a big leap forward and received national recognition as a key driver for development and growth. The gross telephone subscribers in the country reached a level of 272.88 million as of December 2007, with mobile telephone subscriber base rising to 233.63 million. Broadband connections have continued to grow since the beginning of 2006. Total broadband connections in India have reached 4.9 million as of October 2008.

India has taken a leading position in the mobile handsets market. Some of the world renowned mobile set manufacturers have set up production bases for mobile handsets in the country and several others are planning to set up their manufacturing bases in India to meet local demands and cater to international markets.

Strategic Electronics

The strategic electronics segment consists of satellite base communications, navigation and surveillance, underwater electronics and infra-red based detection, disaster management and GPS based vehicle tracking systems.

The Government feels that it is desirable to focus on production in the strategic electronics sector to ensure acquisition of the state-of-the-art technology. The sector is increasingly facing problems in attracting and retaining talent. There is also a trend towards outsourcing/sub contracting and privatisation. At the national level, various research institutions are developing strategic systems and public sector undertakings and some private agencies are contributing towards production. Estimated production of this sector in 2007-08 was Rs. 61 billion.

Electronic Components

The electronics components segment primarily supplies to consumer electronics, telecom, defence, and information technology sectors. The components produced in India at present include TV picture tubes, monitor tubes, diodes and transistors, power devices, ICs, hybrid microcircuits, resistors, capacitors, connectors, switches, relays, magnetic heads, DC micro motors and tape deck mechanism, Printer Circuit Boards (PCB), crystals, loudspeakers and hard and soft ferrites. The growth of electronic components depends on the growth of the other constituents of IT Hardware and Electronics sector to which it supplies.

The world's top five mobile handset makers - Nokia, Motorola, Samsung, Sony-Ericsson and LG have started their manufacturing bases in India. Presence of global majors like Flextronics, Jabil and Elcoteq is creating potential for a quantum jump in hardware manufacturing in India and should have a downstream impact by stimulating demand for components and assemblies.

Most of the top global semiconductor companies have set up their chip design centres in India. The semiconductor products that are expected to drive the revenues are:

- Microprocessor driven by desktops, notebooks and telecom equipment
- Analog driven by mobile phone, monitors and UPS
- Memory driven by desktops, notebooks, servers and telecom infrastructure
- Discrete driven by TV and audio systems, energy meters and converters, mobile and telecom infrastructure.

Others

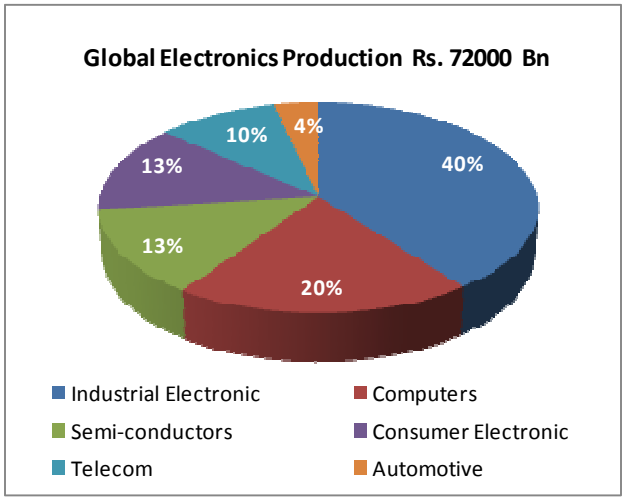
This comprises mainly of the control, instrumentation and industrial sector, having an estimated production of Rs. 119.5 billion in 2007-08. Products include industrial electronics equipment and systems, automation technologies, networking systems and other stand-alone instrumentations used in manufacturing industries like Steel, Textiles, Cement, Power, Chemicals and Refineries etc.

This segment continues to be an important constituent from the perspective of applications for electronics and information technology. Manufacturing of related hardware in technology areas like PLC, distributed control systems, UPS, varied power electronic equipment and systems has been increasing in the country. Newer technologies involving wireless sensors and sensor networking are rapidly emerging as potential application in the field of industrial electronics on account of ease of installation and cost competitiveness.

2.3 Exports from the industry and global competition

The global electronics market was worth Rs. 72,000[1] billion in 2006, which is around 3.6% of world GDP. Its size is estimated to have risen to Rs. 80,000 billion in 2007 and is expected to reach Rs. 128,000 billion in 2012, at a CAGR of 9.8% over the next five years, largely driven by the tremendous growth in consumption of these items in Asia.

Figure 2 : Breakup of global electronics production (2006)



Source: BCC Research.com

Industrial products account for 39.6% of total electronics market, while computers have the second largest share at 20%. Semiconductors make up 13.5%; consumer electronics make up 13.4%; communications

[1] USD converted at an average exchange rate of Rs.40 per USD.

account for 9.9%, and automotive electronics complete the pie contributing 3.6% to the electronics production.

The Asia Pacific, Western European and American (USA, Brazil and Canada) markets contribute to nearly 70%[2] of the world's electronics output. The following section provides a brief overview of each of the main markets of IT Hardware and Electronics Manufacturing Industry.

America

The USA is the world's largest producer of electronic products, accounting for around 21% in the total production and constituting about 29% of the total consumption. High-tech defence and telecom equipment accounts for around 35% of its output.

Canada is a major supplier of sophisticated telecommunication and defence electronic equipment, primarily for export markets. Brazil is the largest producer market for electronics in South America with computer segment accounting for around 43% of its output.

Europe

Western Europe accounts for around 13.2% of the global electronics production with Germany being the largest electronics producer followed by UK, France, Ireland and Italy. Hungary, Russia and Poland are major producers in Eastern/Central Europe. Different countries specialise in different segments of the electronics industry within Europe:

- Computing sector: Belgium, Ireland, Italy and Netherlands.
- Components manufacturing: Denmark, Portugal, Switzerland and Czech Republic.
- Telecommunication equipment: Finland, France, Norway, Spain and Sweden.
- Consumer electronics: Hungary, Poland and Turkey.

Asia Pacific

Electronics output in the Asia Pacific increased to 38% of the global total in 2005 with China's share of global electronics at 16%. Growth in exports has been the key factor in the emergence of China as the world's largest producer of electronic products.

Despite the rapid growth of China, other countries in the region also play an important role in the global electronics industry. South Korea, Malaysia, Singapore and Thailand are all ranked in the top 10 countries globally in terms of production. The growth of China has had a fundamental impact on the Taiwanese

[2] Share in the electronics industry in 2005.

electronics industry, with leading companies relocating production to the mainland to reduce costs. South Korea is a major producer of electronic goods and components accounting for 4% of global output.

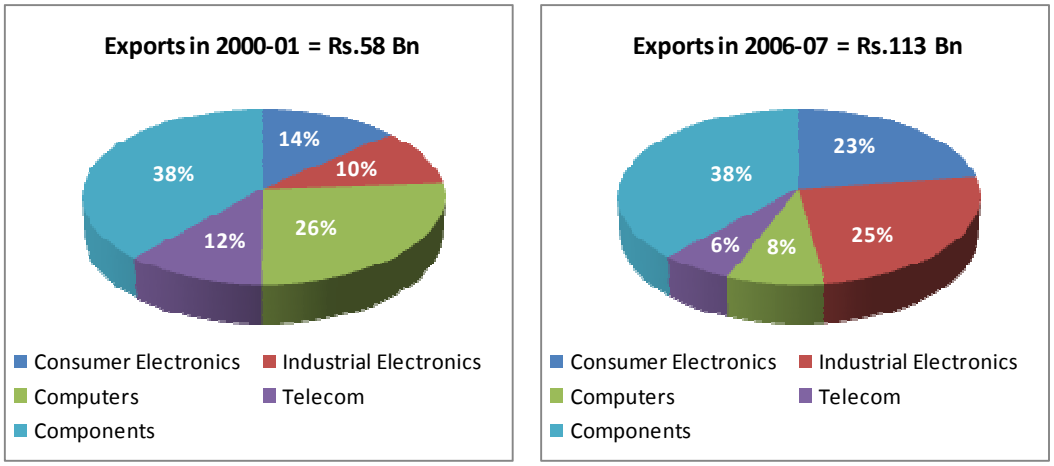
The electronics industry in Singapore and Malaysia, with significant Government support, is looking to focus on higher value products and move away from low-cost assembly. Production of computer equipment in Singapore is a major factor in the country accounting for 7% of global electronics output.

Japan is the world's second largest producer accounting for 15% of the global output. Consumer electronics, once the mainstay of the Japanese electronics industry, continues to lose share as Japanese manufacturers shift production to low cost countries in the Far East.

India

The exports of IT hardware and Electronics from India have increased at a rate of 11.8% from Rs.58 billion in 2000-01 to Rs. 113 billion in 2006-07.

Figure 3 : Breakup of Indian exports by sector



Source: Ministry of Communications and IT

The export of the IT Hardware and Electronics Manufacturing Industry is dominated by the components segment at 38% during the period under review. Consumer and industrial electronics segment have captured a significant share of the exports during the period from 2000-01 to 2006-07. The computers segment has registered a decline in export share from 26% in 2000-01 to 8% in 2006-07 along with the decline in absolute value of exports from Rs.12.5 billion in 2000-01 to Rs. 8.9 billion in 2006-07.

Major destinations for the export of electronic hardware from India are the US, Canada, South Asian countries and the European Union. Almost 60% of exports go to North America, while the EU countries are

the second largest importer of electronic goods from India. Exports to the US include recordable CDs, memory cards, uninterrupted power supplies (UPS), and switching equipment. The major items of export to other Asian countries comprise head stacks, memory cards, UPS, medical appliances, solar cells, semiconductor devices, and picture tubes.

2.4 Production clusters in the country

The production clusters in India are fairly well spread out. The oldest clusters are the ones in Maharashtra, Gujarat and NCR that have existed primarily due to the cheap availability of inputs required for production i.e., land, labour and materials.

The clusters in Karnataka and Andhra Pradesh have come up mainly due to the success of the IT/ ITES industry, to meet the demand for electronics from this sector. The other clusters have come up due to planned interventions/development of the Government granting facilities and benefits to producers/ exporters. The key clusters are as follows:

Table 2 : Key production clusters

Ahmedabad	**Gujarat**
Bengaluru	Karnataka
Gurgaon	Haryana
Hyderabad	Andhra Pradesh
Mumbai	Maharashtra
Abdasa	Gujarat
Agartala	Tripura
Noida	Uttar Pradesh
Pune	Maharashtra
Chennai	Tamil Nadu

Source: UNIDO cluster database

2.5 Policy reforms and initiatives

Until 1984, the electronics sector was dominated primarily by Government-owned companies. The easing of foreign investment norms, allowing of 100% foreign equity, reduction in customs tariffs, and de-licensing of several consumer electronic products in the early nineties attracted remarkable amount of foreign collaboration and investment into the sector. The domestic industry also responded favourably to Government policies. The opening of the electronics industry to the private sector enabled entrepreneurs to establish businesses to meet domestic demand.

To increase exports of hardware as part of a medium-term export strategy from 2002-2007, Government of India emphasised the need to push IT hardware through the Special Economic Zone (SEZ) model and to focus on attracting foreign direct investment in hardware manufacturing. Accordingly, the Electronic Hardware Technology Park (EHTP) scheme is being modified to enable the sector to benefit from the zero-duty regime.

The Government has taken measures to rationalise the duty structure applicable to the electronics industry. For example, customs duty on a number of components has been reduced to nil since 2000. The present customs duty range for components is in the range of 0%-15%. There are rising concerns with respect to the steady rise of the rupee against the dollar which is hitting exports hard.

The Government has recognised the need to focus on the IT hardware industry and investment in hardware to enable it to support the growth of the software industry. The massive projected demand for hardware support growth calls for a high level of investment in the electronics hardware and component industry. Long-term growth will critically depend on large-scale investment in hardware manufacturing and establishing strong linkages with the domestic ancillary industry.

3. Core Processes in IT Hardware and Electronic Manufacturing Industry

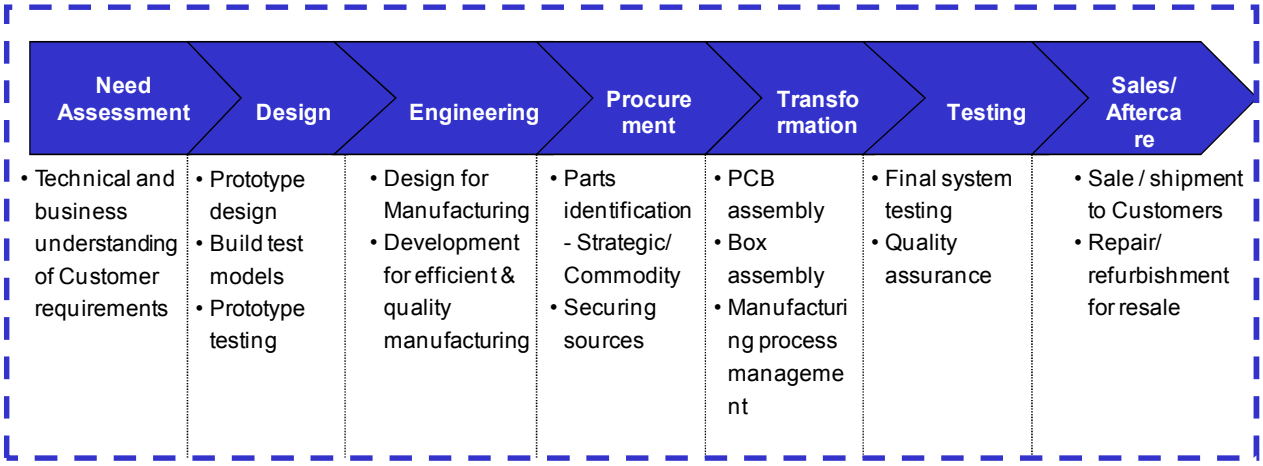
The IT Hardware and Electronics Manufacturing Industry involves a wide range of activities which differ considerably across the different sectors. The activities in the manufacturing function are similar across different sectors, but the scope of sales and after-sales support, quality and development functions differ across various sub-segments. For example, in the case of components, production is the main activity. However, Design and Development, and after-sales support are an integral part of IT Hardware manufacturing. Similarly, for telecom equipment, development is an important activity.

MAIT has studied the key activities in each of these sectors in detail and the same is presented below.

3.1 Consumer Electronics

The consumer electronics sector essentially consists of activities such as need assessment, design development, procurement, transformation, testing, sales and service support.

Figure 4 : Core processes in the Consumer Electronics sector



- *Need Assessment:* This function is almost similar to the need assessment activity discussed under IT Hardware as it involves identifying the customer requirements and converting them into technical and business aspects of production.

- *Design:* Research and development is applied to build test models of a potential new product or enhancements to existing products with a view to develop prototype models and perform its testing.

- *Engineering:* Once a prototype is accepted for further development, it is designed to ensure efficient and high quality manufacturing, with complete design engineering.

- *Procurement:* Strategic and commodity parts are identified and vendors are tied-up for predicted volumes of production.

- *Transformation:* Components and circuit boards are assembled using surface mount technologies (SMT) according to design-engineering specifications with a combination of manual and automated systems to assemble final systems and manage manufacturing process.

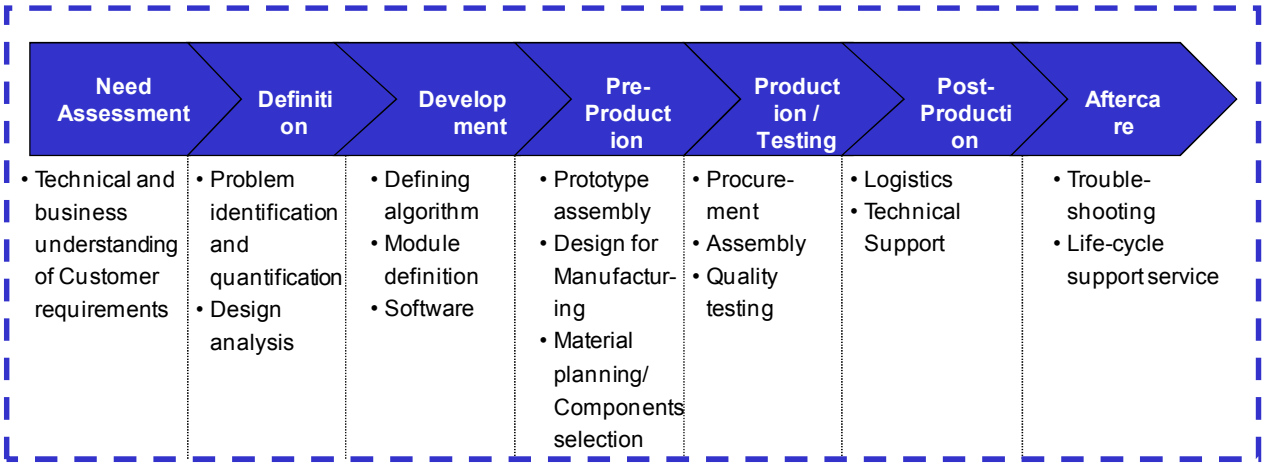
- *Testing:* A combination of manual and automated procedures is used to fully test units coming off the assembly line.

- *Sales/Aftercare:* Finished goods are sold and shipped to end customers. Aftercare will include repair of returned products and repair/ refurbishment of repurchased units to be sold.

3.2 IT related Hardware

The IT hardware sector basically comprises of activities such as need assessment and definition, development, pre-production processes, production, sales and service support.

Figure 5 : Core processes in the IT hardware sector



- *Need Assessment:* For this, a cross functional team comprising of people with background in engineering, manufacturing, materials management, and sales and marketing assess the technical and business aspects of the customer requirements. These are then taken up in further detail by the definition team.

- *Definition:* Based on the need assessment, the engineering team works to define the customer application requirements and help finalise the exact hardware requirements/software configuration. The design concept is then chalked out considering the hardware configuration and cost estimates during the complete manufacturing process.

- *Development:* With the aid of algorithm engineering, i.e. a combination of theoretical algorithm design with real-world data via a hardware device, verification of algorithm results and behaviour is ascertained. Definition module includes packaging of various units which has a well-defined interface with the other components, and developing the enabling software for hardware to function.

- *Pre-Production*: The pre-production process begins with prototype assembly to identify the manufacturing process and finalise the product design. The design for manufacturing analysis is performed to point out cost reduction and system improvements at the prototype level. Further, to achieve desired quality and price level, best available components are identified for the product design.

- *Production/Testing:* Best-in-class components at competitive prices need to be procured from the existing/new vendors developed for assembly process. Assembly services shall provide complete box-build and full system assembly for the computing hardware and finally conclude the production process with functional and system testing.

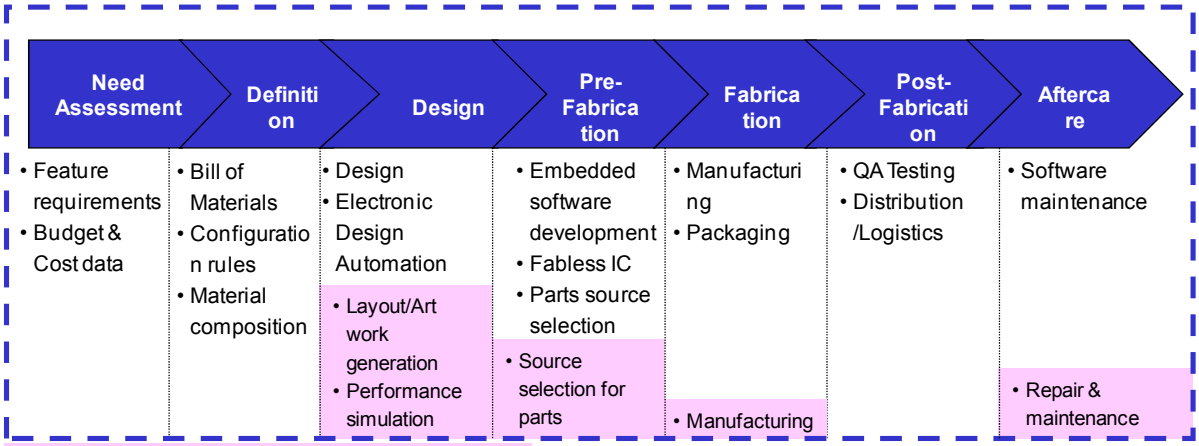
- *Post-Production:* This includes arranging logistics and providing technical support for the product.

- *Aftercare:* This includes post sales trouble-shooting and repair and maintenance. Managing and providing life-cycle support service for the product.

3.3 Components (Active/ Passive)

Components sector essentially consists of activities such as need assessment, definition, design development, pre-fabrication, fabrication, post fabrication and technology support. Certain activities differ across active /passive components categories and have thus been accordingly highlighted in the process diagram for the components Industry.

Figure 6 : Core processes in the Components sector



- *Need Assessment:* Based on the customer requirements, product functionality, budget, data analysis is performed to ascertain estimated cost and design feasibility.

- *Definition:* Definition will include preparing bill of materials, finalising configuration rules and the material composition of the component.

- *Design:* This includes designing hardware specifications and developing tools for producing active component systems. For passive components, design stage key activities include layout/art work generation, e.g. developing layout for integrated resistors and its performance simulation.

- *Pre-Fabrication:* The key activities in pre-fabrication stage include embedded software development and fabless IC (no fabrication integrated circuit development) and finalising sources of parts supply. For passive components, pre-fabrication includes selection of source for parts only.

- *Fabrication:* This includes manufacturing and packaging of active components. For passive components, manufacturing is the key activity.

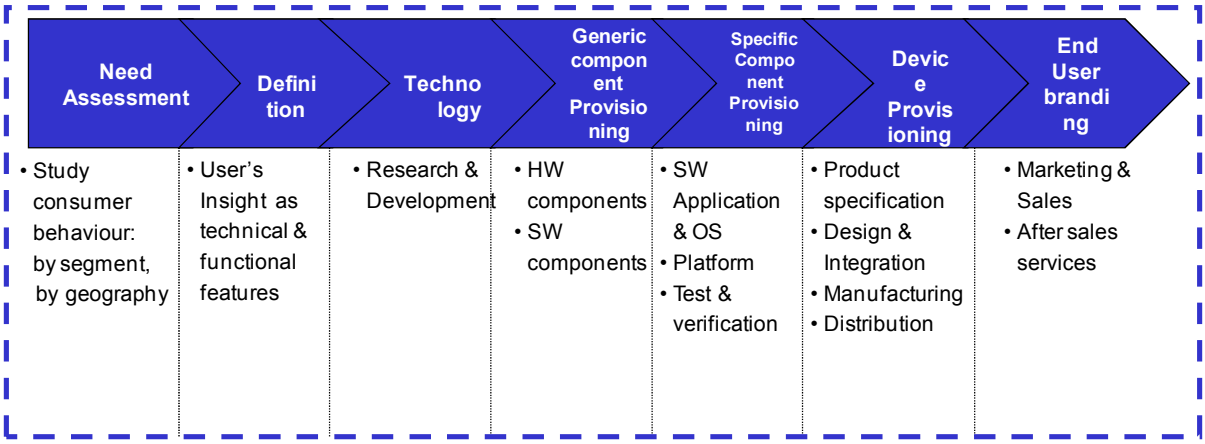
- *Post-Fabrication:* Quality assurance testing and distribution/logistics arrangement are the post-fabrication activities for components.

- *Aftercare:* This includes software maintenance for the active components. For passive components, repair & maintenance are the key aftercare activities.

3.4 Telecom Equipment

Telecom equipment segment consists of the activities such as need assessment, definition, technology identification, assembling and provisioning, sales and technology support.

Figure 7 : Core processes in the Telecom equipment sector



- *Need Assessment:* As telecom equipment, namely mobile handsets, are required to be designed for different geographic markets and price points, incorporating consumer behaviour - by segment, by geography is an integral part of the design process.

- *Definition:* The user's insight is built into technical and functional features of the telecom equipment in finalising the design specification.

- *Technology:* Research & Development is performed to develop product technology suitable for the product.

- *Generic Component Provisioning:* Hardware design (proprietary or standard), its development and manufacturing are completed. Standardised software, software, such as environment engines, is finalised.

- *Specific Component Provisioning:* Platform/reference design, a combination of software and hardware components is finalised after developing software application and operating system and software system (an integration of different software components). Testing is done for verification of smooth operating performance.

- *Device Provisioning:* End use device specifications are finalised for design and integration like platform, hardware component and software application. Physical assembly and production is carried out and distribution of products is arranged.

- *End User Branding:* This includes devising the marketing and sales strategy for direct marketing to end-customers and brand owned sales channel through dealers and distributors. After-sales service refers to repair and maintenance activities.

4. Current employment and future potential in the industry

The current employment pattern in IT Hardware and Electronics Manufacturing Industry varies depending on the level of value-chain that the companies are operating at. Most of the production units have a higher concentration of people at the worker/operator level whereas research and development companies have a large proportion of workforce with advanced technical skills. Accordingly, the level of education of the workforce also varies depending on the business activities undertaken by the companies in various sectors.

4.1 Functional distribution of people across sectors

During our interaction with various companies, we analysed the proportion of workforce at various functional levels across different sectors.

Table 3: Function-wise breakup of manpower across sectors in IT Hardware and Electronics Manufacturing Industry

	R&D	Manufacturing	Sales	After-sales support	Administration
Consumer Electronics	4%	50%	27%	14%	5%
IT related hardware	3%	21%	25%	41%	10%
Telecom Equipment	4%	30%	30%	30%	6%
Strategic Electronics	12%	46%	8%	20%	13%
Components	16%	62%	8%	6%	8%
- Manufacturing	0%	78%	8%	7%	7%
- Design	81%	0%	8%	0%	11%

Source: Primary survey of leading players across sectors, IMaCS analysis

Consumer electronics: This sector has a significant workforce involved in manufacturing operations, followed by the sales function. Manufacturing accounts for nearly 50% of the workforce in the industry, with Sales accounting for another 27%. Usually after-sales support is handled by a central office in a key location, with a certain part being outsourced to local trade partners.

IT related hardware: In the case of IT hardware and peripherals, after-sales support of own product and third party products is an important line of business and hence accounts for the majority of the workforce – roughly 41% of total workforce. Sales function accounts for 25% of the employment. Production processes are automated resulting in lesser percentage of manpower employed in manufacturing.

Telecom equipment: Telecom equipment manufacturers have an almost equal proportion of people employed in production processes (including quality check), sales (generally done through an institutional network of dealers and distributors which is managed by the company's sales force) and after-sales support (at times outsourced to other trade partners and only trainers are employed in the after-sales function for imparting training to the outsourced workforce and handling more critical repairs).

Strategic Electronics: Maximum manpower is involved in production, followed by service and support.

Components: Within component manufacturing, a large number of players are only engaged in manufacturing activities with little or no thrust on design and R&D. Since the production is undertaken as contract manufacturing, sales is an important but not a highly staffed function with prime focus on new customer acquisition and retention of existing clients. On the other hand, a few companies specialise in designing of custom-specific components where R&D function employs the maximum number of people.

4.2 Distribution of manpower by education level

The following table represents the education-wise break-up of people across various sectors of the industry.

Table 4: Education-wise breakup of manpower across sectors in IT Hardware and Electronics Manufacturing Industry

	Ph. D/ Research	Engineers	Diploma or equivalent certification by other agencies	ITI and other vocational courses	Other graduates	CA/MBA/etc.	12th/10th standard
Consumer Electronics	3%	9%	10%	7%	27%	22%	22%
IT related hardware	4%	20%	25%	10%	19%	6%	16%
Telecom Equipment	5%	40%	20%	7%	15%	6%	8%
Strategic Electronics	6%	37%	22%	10%	10%	5%	10%
Components	6%	28%	13%	16%	3%	2%	32%
Manufacturing	*1%*	*20%*	*15%*	*20%*	*2%*	*2%*	*40%*
Design	*25%*	*60%*	*5%*	*0%*	*8%*	*1%*	*1%*

Source: Primary survey of leading players across sectors, IMaCS analysis

Consumer electronics: This sector employs a significant proportion of 10^{th} / 12^{th} pass workers, with basic training on machines and equipments. They account for roughly 22% of employment. Graduates (Arts/ Science/ Commerce) are recruited for sales and administration functions. Diploma holders and engineers are involved in the manufacturing operations. ITI pass-outs are primarily employed for maintenance related jobs.

Telecom equipment: Engineers are employed for supervision of production, quality function and sales. Diploma holders and ITI pass-outs are essentially employed for maintenance and after sale support activities.

IT related hardware: In this sector, diploma holders and ITI pass-outs are primarily engaged in production and after-sales function. Engineers are usually involved in supervisory roles in production and in some cases handle the sales function. Graduates (Arts/ Science/Commerce) are employed for administration jobs.

Components: Component manufacturers employ a large number of people having basic school education. The production processes are well streamlined and repetitive, thus workers are given basic training and are supervised by engineers/diploma holders. Component companies engaged in design and R&D employ highly technical staff, primarily engineers (including both B Tech and M Tech). Graduates (Arts/ Science/ Commerce) are employed for administrative function.

Strategic Electronics: Maximum manpower is involved in production, which comprises mainly of Engineer and Diploma holders.

It should be noted that some of those employed at 10^{th}/12^{th} levels have learnt on-the-job while others are exposed to some basic vocational training in the company. Certain others are employed as helpers and basic operators. Formal training in this section of the workforce would be of additional benefit to the industry as a whole.

4.3 Manpower requirement by 2015 – by function and by education level

The human resource directly employed in the industry is currently estimated to be roughly 770,000 (as per the Council of Electronics Hardware Associations). It is estimated that the consumption of electronic equipment would be USD 126 billion by 2010 and around USD 360 billion in 2015, growing at compound annual rate of just under 30%. Along similar lines, industry currently estimates that the production of electronic equipment in India would touch USD 58 billion in 2010 and USD 155 billion in 2015, from the level of USD 11 billion in 2005, growing at over 30% compounded annually.

However, the historical growth rate of the industry has hovered at around 15%, Our analysis indicates that a growth rate of around 20% would be a 'likely' scenario for industry growth. A 20% growth rate could be targeted based on expected investments and that fact the electronics industry could aspire to be among the fast growing industries in the light engineering sector. Consequently, while our detailed analysis outlined below presents estimates based on a growth rate of 20% in the industry, we shall also present a sensitivity analysis of key industry parameters to the growth rate at the end of the section which will also include the scenario based on the continuation of the existing growth of about 15% in the industry.

4.4 Forecasted industry size

Our analysis indicates that the IT Hardware and Electronics Manufacturing sector would amount to more that Rs. 2800 billion in 2015 from the current size of over Rs. 800 billion.

Table 5 : Forecasted size of industry by sector – 2009-2015

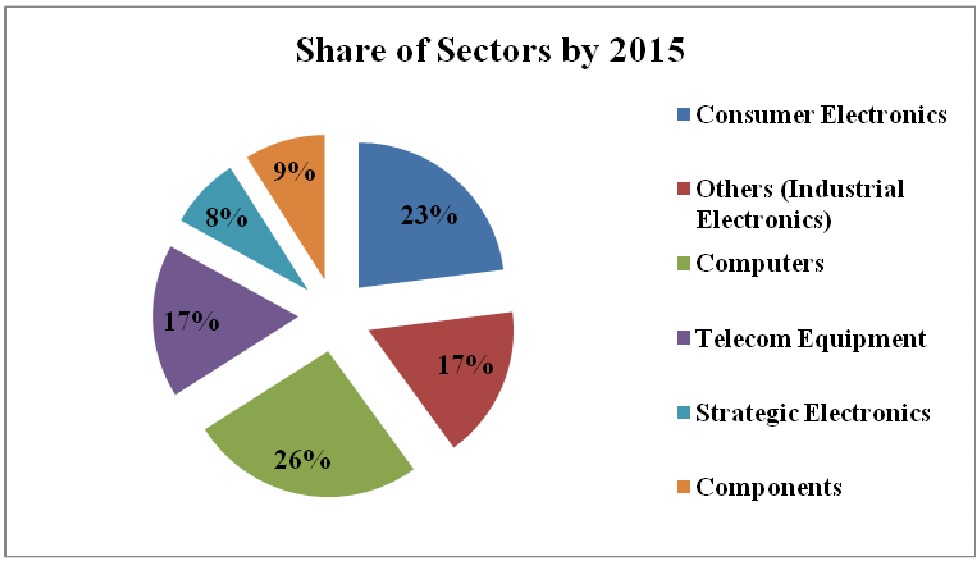
Rs. Crore

Size of industry	2009	2010	2011	2012	2013	2014	2015	CAGR
Total	**95,040**	**114,048**	**136,858**	**164,229**	**197,075**	**236,490**	**283,788**	**20%**
Consumer Electronics	26,881	31,165	36,131	41,888	48,562	56,300	65,271	16%
Others (Industrial Electronics)	15,263	18,490	22,399	27,136	32,873	39,824	48,244	21%
Computers	19,833	24,688	30,732	38,255	47,619	59,275	73,785	24%
Telecom Equipment	14,261	17,473	21,408	26,230	32,138	39,376	48,244	23%
Strategic Electronics	6,744	8,256	10,108	12,374	15,148	18,545	22,703	22%
Components	12,057	13,975	16,080	18,347	20,735	23,170	25,541	14%

Source: Council of Electronics Hardware Associations, IMaCS analysis

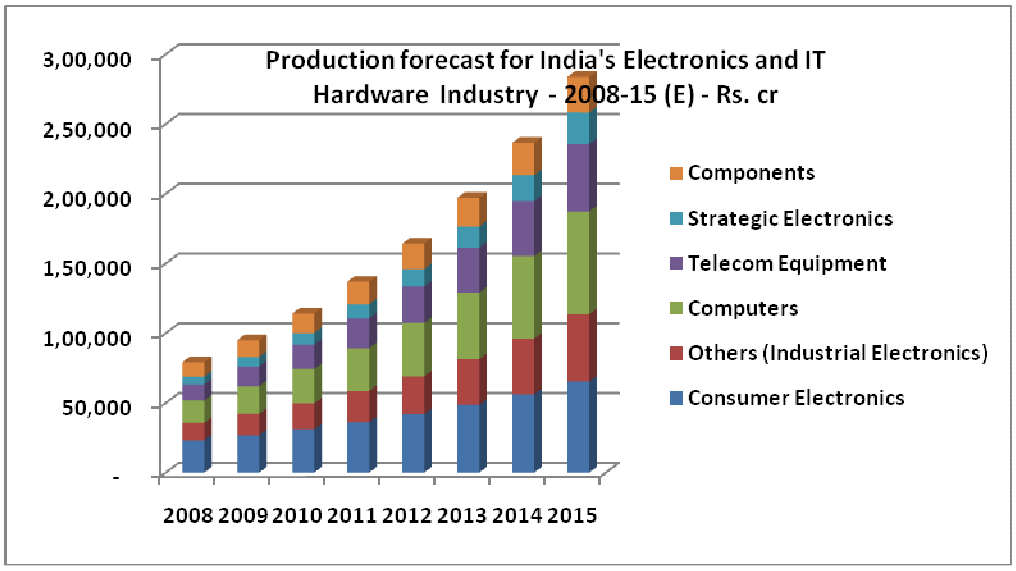
The share of various sectors is expected to change from current levels as shown below due to the high 25% growth projected for the computers and telecom equipment sectors.

Figure 8: Forecasted share of various sectors by 2015



Source: IMaCS analysis

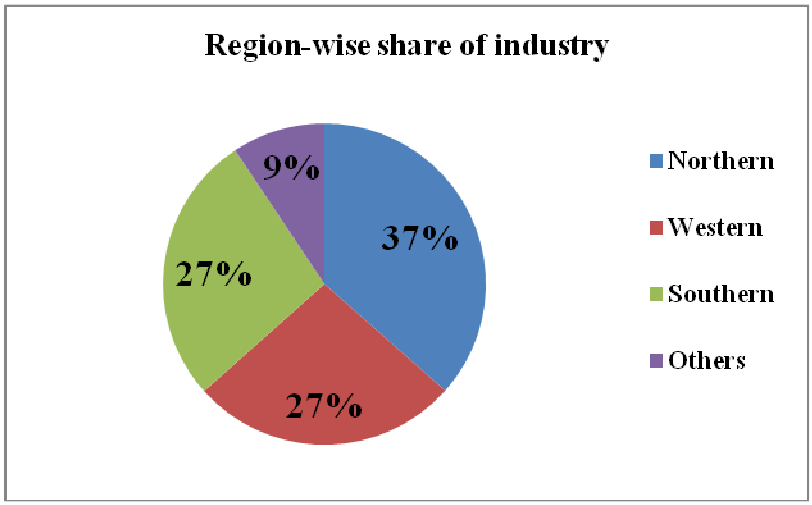
Figure 9 : Composition of the Electronics and IT Hardware industry between 2008-15



Source: IMaCS analysis

The Northern region, comprising of Uttar Pradesh, Himachal Pradesh, Punjab, Uttaranchal, Haryana, and Delhi (NCR) is the leader in the IT Hardware and Electronics Manufacturing Industry. This is followed by the Western (Maharashtra, Gujarat, Rajasthan) and Sothern regions (Karnataka, Andhra Pradesh, Tamil Nadu, Pondicherry), which enjoy almost equal share. The share of various regions is illustrated in the following figure.

Figure 10 : Region-wise share of industry



Source: Annual Survey of Industry, IMaCS analysis

It is estimated that the Northern region would continue to retain its leadership position in the share of industry.

Table 6: Forecasted region-wise share of IT Hardware and Electronics Manufacturing

Industry size region-wise by 2015	Rs. cr
Northern	103,632
Western	76,350
Southern	77,252
Others	26,554

Source: IMaCS analysis

4.5 Human Resource Requirement till 2015

It is estimated that about 2.25 million persons would be directly employed in the industry by 2015 from the current level of 0.77 million. The incremental human resource requirement is estimated to be at around 1.5 million persons.

Table 7 : Incremental human resource requirement 2007-2015

	2007	2015	Incremental
Total	**779,255**	**2,254,204**	**1,474,949**
Consumer Electronics	189,394	423,112	233,718
Others (Industrial Electronics)	131,313	292,825	161,512
Computers	161,616	694,186	532,570
Telecom Equipment	97,256	358,122	260,866
Strategic Electronics	56,818	203,280	146,462
Components	142,857	282,678	139,820

Source: IMaCS analysis

The incremental human resource requirement is expected to be the highest in the computers, consumer electronics and telecom equipment sectors. By 2012, the industry would employ about 1.49 million persons, which implies an incremental requirement of about 0.7 million persons across various sectors.

Table 8 : Incremental human resource requirement till 2012

Sector	2007	2011-12	Incremental
Total	779,255	1,489,609	710,354
Consumer Electronics	189,394	313,002	123,608
Others (Industrial Electronics)	131,313	194,601	63,287
Computers	161,616	401,887	240,271
Telecom Equipment	97,256	219,654	122,398
Strategic Electronics	56,818	126,035	69,217
Components	142,857	234,430	91,573

Source: IMaCS analysis

The incremental human resource requirement for 2009 alone is expected to be around 0.13 million over that of 2008.

Table 9 : Immediate requirement for 2009 over that of 2008

Immediate human resource requirement	Incremental requirement for 2009
Electronics and IT Hardware Industry in India	**127,084**
Consumer Electronics	22,134
Others (Industrial Electronics)	16,468
Computers	38,752
Telecom Equipment	20,257
Strategic Electronics	11,510
Components	17,963

Source: IMaCS analysis

Apart from manufacturing and sales, the service support function has emerged as a key employment generator in the industry. In 2015, service support is expected to be the next highest employment generator after manufacturing. In addition, there is demand for specialised skills such as R&D – more than 80,000 people are expected to be engaged in the design function by 2015.

Table 10 : Incremental human resource requirement in different functions across sectors toll 2015

Sector	R&D	Manufacturing	Sales	After sales service support	Administration
Consumer Electronics	9,349	116,859	63,104	32,721	11,686
Others (Industrial Electronics)	4,845	116,935	24,227	8,076	7,430
Computers	15,977	111,840	133,142	218,354	53,257
Telecom Equipment	10,435	78,260	78,260	78,260	15,652
Strategic Electronics	17,575	68,032	11,717	29,878	19,260
Components	22,651	87,248	11,186	7,830	10,906
Total requirement in the Industry	**80,832**	**579,173**	**321,636**	**375,118**	**118,190**
Incremental human resource requirement			**1,474,949**		

Source: IMaCS analysis

The incremental human resource requirement across various educational qualifications reflects the demand for skill sets across various sectors.

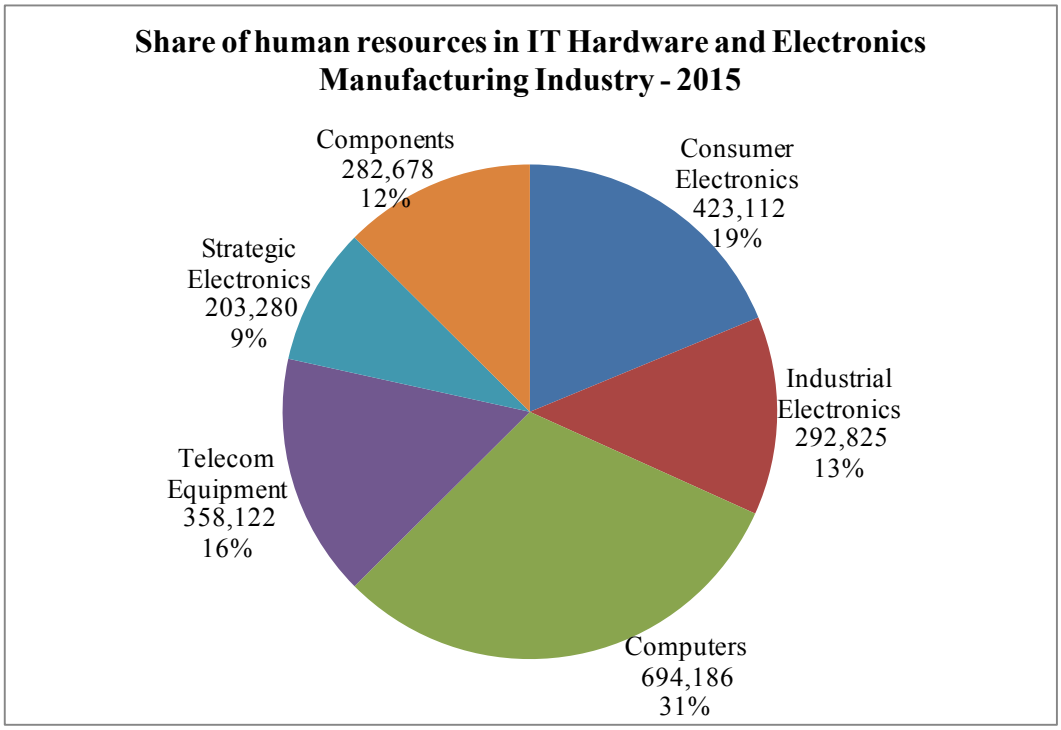
Table 11: Incremental human resource requirement in different education qualifications till 2015

Incremental human resource requirement in different educational backgrounds till 2015	Ph.D and Research scholars	Engineers	Diploma and other equally certified skills	ITI and other vocational courses	Other graduates such as B.Sc	MBA/CA/ CWA	10th / 12th
Consumer Electronics	7,012	21,035	23,372	17,061	63,104	51,418	50,717
Others (Industrial Electronics)	4,845	64,605	16,151	10,660	4,845	8,883	51,522
Computers	21,303	106,514	133,142	53,257	101,188	31,954	85,211
Telecom Equipment	13,043	104,346	52,173	17,217	39,130	14,348	20,608
Strategic Electronics	8,788	54,191	32,222	14,361	14,800	6,920	15,181
Components	7,774	39,150	18,121	22,399	4,782	2,657	44,938
Total requirement in the Industry	**62,765**	**389,841**	**275,181**	**134,955**	**227,849**	**116,180**	**268,178**
Incremental human resource requirement				**1,474,949**			

Source: IMaCS analysis

The share of human resources as forecasted in the year 2015 is about 2.25 million. The share in different sectors of the industry is as shown in the following figure.

Figure 11: Share of human resources in different sectors in the IT Hardware and Electronics Manufacturing Industry - 2015



Source: IMaCS analysis

Numbers indicate human resource requirement, % indicate share of the sector with respect to share of human resources required

4.6 Sensitivity analysis

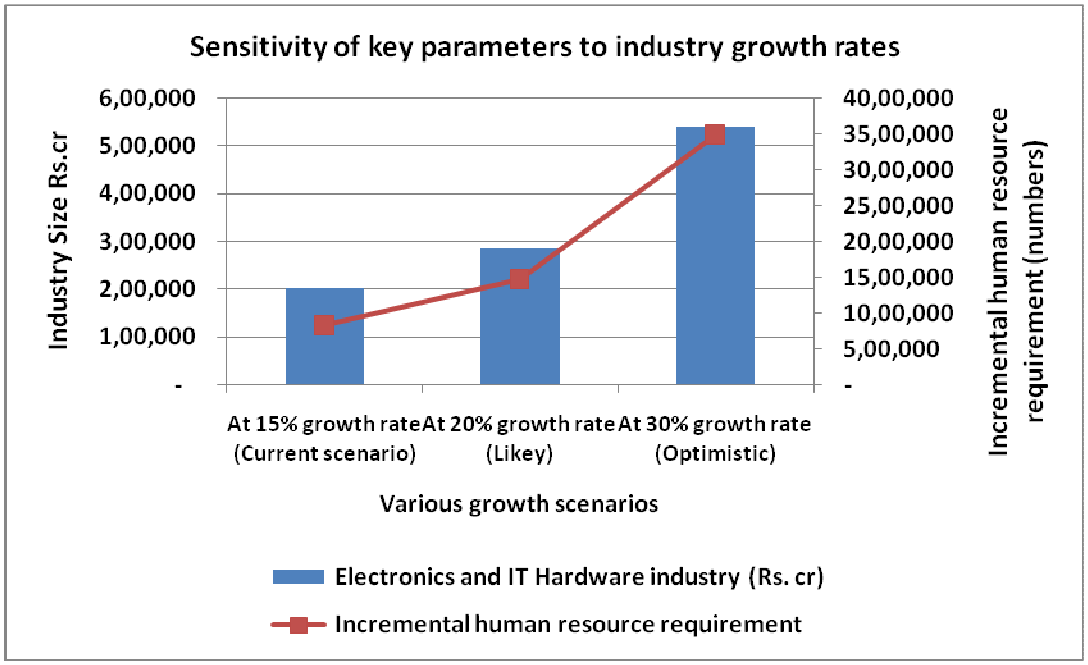
The following graph presents the sensitivity analysis of key industry indicators for various scenarios of industry growth rates. Our calculations for forecasted manpower in the earlier section have assumed an industry growth at a CAGR of 20% till 2015, indicating a total manpower requirement of 2.25 million people (incremental requirement being 1.5 million people).

The sensitivity analysis has been performed for the following two scenarios:

Scenario 1: In this scenario we have assumed a 15% CAGR in industry size till 2015 (the growth rate continues to remain at the current level). This implies the industry size would be roughly Rs. 2000 billion in 2015, requiring roughly 1.6 million people in the industry (incremental requirement being 0.8 million people).

Scenario 2: In this scenario we have assumed a 30% CAGR (most optimistic scenario) in industry size till 2015. This implies the industry size would be about Rs. 5400 billion in 2015, requiring a total of nearly 4.3 million people in the industry (incremental requirement over 3.5 million people).

Figure 12: Sensitivity analysis for forecasted manpower requirement



Source: IMaCS analysis

This scenario, which implies higher value addition in the IT Hardware and Electronics Manufacturing Industry, is subject to significant growth in emerging areas (outlined in *Box 6* in the section on *Recommendations*) as well as increased market penetration of existing products. In this scenario, the incremental human resource requirement would span out as follows.

Table 12: Incremental human resource requirement 2007-2015 under Scenario 2 (with higher value addition)

Forecasted human resource requirement 2007 - 2015	2007	2015	Incremental
Electronics and IT Hardware Industry in India	**779,255**	**4,276,515**	**3,497,260**
Consumer Electronics	189,394	802,699	613,305
Others (Industrial Electronics)	131,313	555,528	424,214
Computers	161,616	1,316,960	1,155,344
Telecom Equipment	97,256	679,404	582,148
Strategic Electronics	56,818	385,649	328,830
Components	142,857	536,276	393,419

Source: IMaCS analysis

This human resource requirement would be distributed in the proportion indicated in Table 3 and 4 under various functional and educational qualification requirements.

Scenarios 1 and 2 have been detailed in the Annexure.

5. Skill requirement in the industry

MAIT has reviewed the hierarchy in various critical functions of the IT Hardware and Electronics Manufacturing Industry in India. The key functions are explained in detail below along with the various levels of employment within each of them. The various key functions are identified as:

- Production
- Sales
- Design and Development
- Quality assurance
- After-sales service
- Software Development.

This section presents the skill requirements in the IT Hardware and Electronics Manufacturing Industry.

5.1 Skill requirements in the Production function

In the Production function, there are five distinct levels – Production Manager, Shift Engineer, Line Supervisor, Operator/Technician and Casual Worker. Of these, the roles of the Line Supervisor and the Operator/Technician level are critical. For various skill levels in the manufacturing function, key activities performed and the qualification required are as follows:

Figure 13 : Roles in Production function and qualifications required

Production Manager	***Key Role:*** Overall management of employees/processes, planning high level targets and ensuring smooth operations ***Qualification:*** BE & MBA, BE/B. Tech & M. Tech/ MS from electronics, ECE, mechanical, instrumentation streams with 8-10 years of experience in manufacturing
Shift Engineer	***Key Role:*** Managing production-shifts/ monitoring technicians and supervisors, quality checks, on job training, process improvements through time and motion studies ***Qualification:*** BE/ B. Tech / M Tech (Electronics, ECE, Mechanical, Instrumentation) with 6-8 years experience on shop floor
Line Supervisor	***Key Role:*** Ability to maintain low downtime on machines, line balancing to ensure the production targets are met by operators ***Qualification:*** Diploma Engineers (Mechanical, Electronics, and Instrumentation) with 4-5 years experience
Operator/ Technician	***Key Role:*** Ensuring production as per production planning and targets, regular and preventive maintenance of manufacturing equipments, operating fork lift trucks/ conveyor belts, CNC machines and robots ***Qualification:*** Diploma Engineers, ITI pass-outs specialising in electrical/mechanical
Worker/ Helper	***Key Role:*** Materials and machine handling, loading/unloading, packaging, store keeping ***Qualification:*** 10th Pass and above with basic equipment handling know-how

The levels in manufacturing function in a particular unit vary depending on the size and scale of operations. For example, small and medium component manufacturers/contract manufacturers for OEM usually have four levels, instead of the five levels indicated earlier, comprising of casual worker, technician, line supervisor and production in-charge. The functional and soft skills required at each of the above levels are as follows:

Production Manager: A Production Manager is responsible for ensuring goods are produced to the right quality and quantity, and in the most efficient way. The typical skills required at this level include:

- Project management skills, including excellent organisational and planning skills in order to plan, monitor and alter production schedules when necessary
- Ability to identify and encourage innovative and productive activities among workers/methods of production
- Strong knowledge of the production process and ability to oversee all parts of the production process including logistics and quality control
- Ability to liaison with suppliers regarding quality, price, delivery times and ethical standards, including finding new sources of supply
- Ability to overcome production-related issues, such as machine faults by overseeing the work of maintenance technicians, and liaising with in-house design and sales teams
- Ability to work under pressure, multi-task and meet deadlines
- Ability to overcome problems and handle conflict
- Knowledge of budgeting and cost management techniques
- Strong communication skills.

Shift Engineer: A person at this level is expected to supervise the production activities during a shift. Besides strong technical knowledge, he is expected to have planning skills in order to meet the production targets for the shift by division of work among line supervisors. The typical skills required at this level include:

- Ensuring achievement of targets as per production plan drawn by the Production Manager
- Developing the maintenance schedule for upkeep of plant and equipment and communicating the same to the line supervisors for adherence
- Problem solving skills to minimise the downtime and optimise the production of shift with minimum defects and re-working
- In-depth technical knowledge of assembly line process and procedures for preparing the Standard Operating Manuals in liaison with Production Manager to be followed by technicians/operators

- Strong understanding of and focus on cost reduction and productivity improvement with the aid of time and motion studies
- Ensuring compliance with on–the job training schedule and conducting workshop for skill enhancement of technicians and operators.

Line Supervisor: A person at this level is expected to handle all activities along a production line. Besides strong technical knowledge, he is expected to have good people management skills in order to get work done from operators and workers. The typical skills required at this level include:

- Ability to meet the production target of a particular line, while ensuring adequate supply of material, adherence to quality parameters and maintenance schedule
- Material management skills to eliminate wastages and strong knowledge of process to followed to eliminate defective production/re-working
- Ability to fix production targets for workmen, clearly communicate instructions to operators and workers and measure their performance against these targets
- Problem solving ability
- Providing on–the job training and mentoring of the operators/technicians.

Operator/Technician: An Operator/Technician is responsible for carrying out the production related activities. At this level, personnel are also dedicated specifically for maintenance of machines, for which knowledge of machinery is essential. The skills required at this level are as follows:

- Practical skills for using technical equipment and machinery
- Ability to follow instructions and understand operating manuals for strict adherence
- Ability to identify defects and rectify them
- Ability to ensure minimum wastage
- Ability to work in a team as well as on an individual basis
- Awareness of health and safety standards
- Knowledge of quality standards
- Adaptability to new processes/production lines.

Helpers: A helper is responsible for supporting the production process through management of material on shop floor. In order to ensure smooth operations, the skills required at this level are as follows:

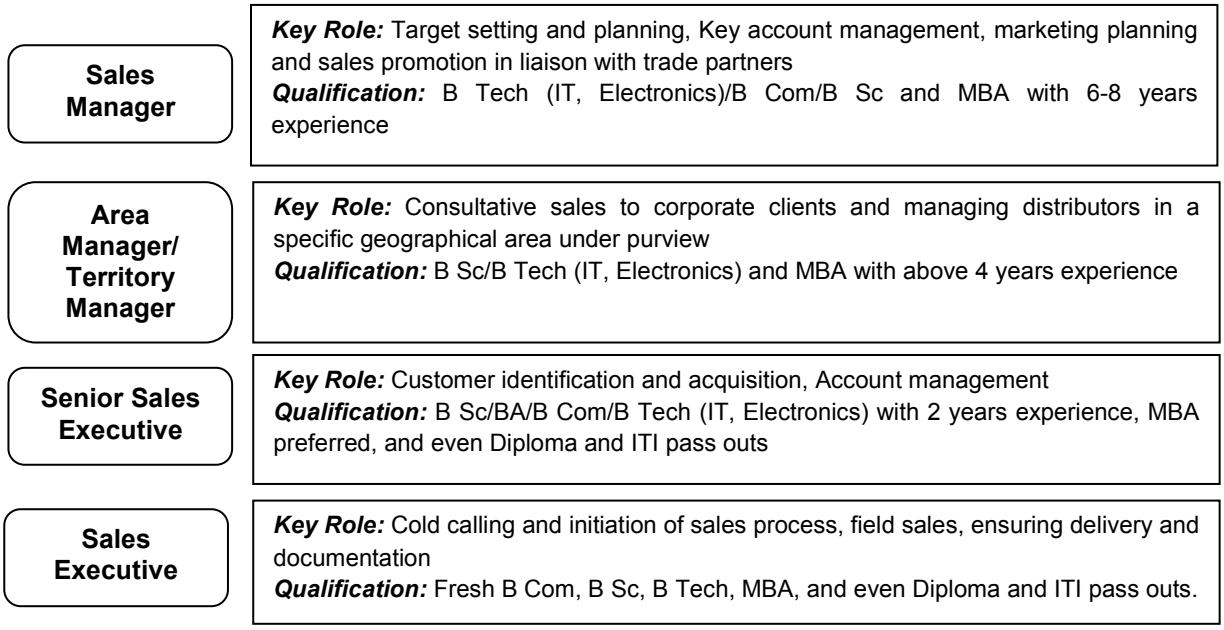
- Ability to understand instructions
- Symbol comprehension and basic reading skills
- Ability to identify deviations in material and inform the operators/supervisor
- Awareness of health and safety standards

- Punctuality at work.

5.2 Skill requirements in Sales function

In the sales function, there are usually four skill levels – Sales Manager, Area/Territory Manager, Senior Sales Executive and Sales Executive, depending on their work experience and responsibilities handled. Of these, the roles of Sales Executive and Sales Manager are critical. For various skill levels in the sales function, the key activities performed and the qualifications required are as follows:

Figure 14 : Roles in Sales function and qualifications required



The levels in the sales function differs depending on size of the business. Component manufacturers as well as small assembly units usually hire a few Account Managers (equivalent to Senior Sales Executive in a larger firm), whose primary responsibility is new customer acquisition and maintaining existing client relationships. Consumer electronics and telecom companies generally employ MBAs with graduation in Arts, Science and Commerce streams for their sales function. Component manufacturers and IT Hardware companies employ MBAs with engineering background for their sales role, largely because of the technical nature of the products and emphasis on customisation of products. A significant portion of Diploma and ITI pass-outs are employed at the lower levels of the sales force too.

The functional and soft skills required at each of the above levels are as follows:

Sales Manager: A Sales Manager is expected to set targets and ensure that these targets are achieved, manage key accounts and undertake sales promotion in liaison with trade partners. The typical skills required at this level include:

- Negotiation skills to settle favourable commercial terms with channel partners in various territories
- Knowledge about industry trends and competition
- Knowledge of own product features and functionalities
- Knowledge of budgeting and cost management techniques
- Strong understanding of commercial aspects of transaction and pricing techniques
- Strong communication skills
- Ability to manage teams and get the sales force to achieve its target
- Performance measurement through daily and weekly reports and devise the strategy to meet shortfalls, if any.

Area Manager/Territory Manager: A person at this level is expected to achieve the sales target for a particular geographic area under review and manage the trade channel in a particular location. The typical skills required at this level include:

- Strong networking skills to maintain relationship with clients and distributors
- Strong communication skills
- Knowledge about industry, competition, own product, product innovations and emerging trends
- Ability to manage and monitor leads generated and referred, tracking follow-up and closure
- Knowledge about commercial aspects of transactions such as pricing and promotional schemes to ensure adequate profits and achievement of sales targets
- Manage daily sales plans for market development and performance measurement using key metrics like daily sales-out, width, depth and reach
- Ability to co-ordinate channel activities like training Sales Executives in products and applications, sales techniques, route planning for sales calls, competitive counters, etc.

Senior Sales Executive: A person at this level is expected to handle key customer accounts and obtain sales closure, apart from mentoring Sales Executives. He is expected to have good people management skills in order to gainfully employ Sales Executive. The typical skills required at this level include:

- Ability to identify customer requirements and making the sales pitch accordingly
- Thorough knowledge of the products and ability to cross-sell/up-sell
- Ability to train junior people and productively utilise them for achieving sales target
- Good relationship management skills
- Liaisoning skills with trade partners/channel management

- Awareness about trends in the industry and competitors offerings
- Good communication skills
- Ability to undertake database management, record keeping and MIS.

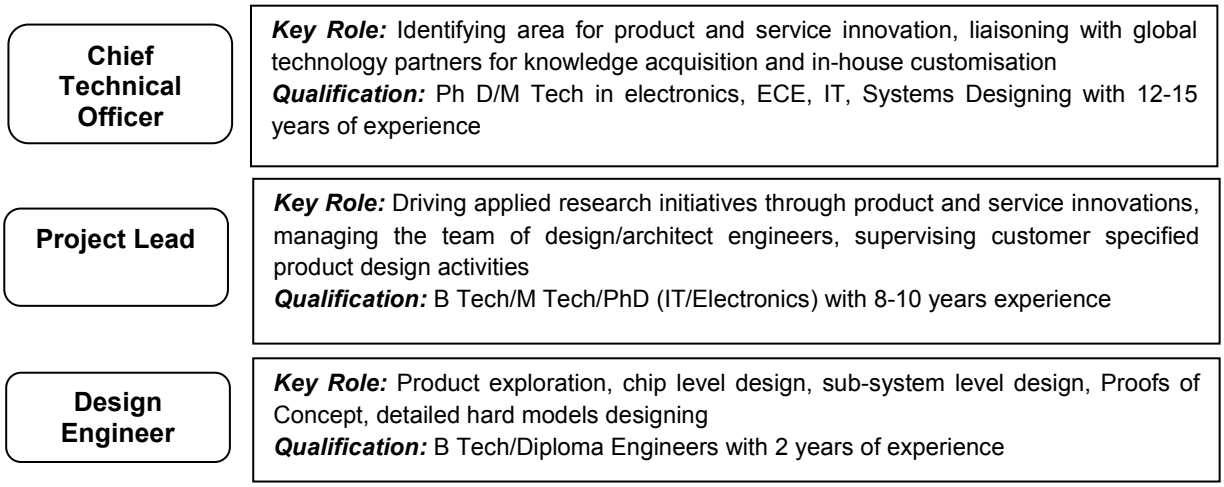
Sales Executive: A Sales Executive is responsible for identifying the prospects, following-up and documentation and delivery. The skills required at this level are as follows:

- High degree of aggression and energy required
- Good communication skills
- Ability to follow up properly and perseverance required
- Thorough knowledge of the product being sold and ability to draw comparisons with competing products
- Ability to undertake cold calling and prospecting
- Good relationship management skills.

5.3 Skill requirements in Design and Development function

In Design and Development function, the key levels are Architect/Design Engineer, Project Lead and Chief Technical Officer. For various skill levels in this function, key activity performed and the qualification required are as follows:

Figure 15 : Roles in Design and Development function and qualifications required



The Design and Development activities are not carried out by all the companies in the IT Hardware and electronics domain. Component manufacturers/small assembly units typically obtain product prototypes which are then converted to production specifications and manufacturing activities are accordingly carried

out. Telecom players and IT hardware manufacturers typically have in-house Design and Development functions. Companies specialising in components design such as ST Micro-electronics, Flextronics and Intel conduct research and development at a much wider scale.

The functional and soft skills required at each of the above levels are as follows:

Chief Technical Officer: A Chief Technology Officer should be thoroughly knowledgeable person with awareness about latest product and service innovations. The typical skills required at this level include:

- Knowledge about the latest technology and industry trends, sound technical background, understanding of and ability to identify research opportunities
- Networking skills and strong contacts with researchers/academicians worldwide
- Knowledge of applicable quality standards and ability to improve/devise the standards in co-ordination with Quality Department
- Ability to develop a team, proactively identify training needs of team and develop them
- Ability to supervise and guide the research team regarding the research activities
- Strong goal orientation.

Project Lead: A person at this level is expected to supervise particular design/development projects and ensure deliverable management. The typical skills required at this level include:

- Knowledge about the latest technology and industry trends, sound technical background, understanding of and ability to manage research activities – new trends in VLSI and embedded
- Ability to co-ordinate characterisation and test efforts with an objective of commercialisation of the product/service innovation
- Ability to lead a team of Design/Architect Engineers by providing clear cut instructions
- Project management skills
- Strong communication and trouble shooting skills.

Design Engineer: The key role of a person at this level is product exploration. The typical skills required at this level include:

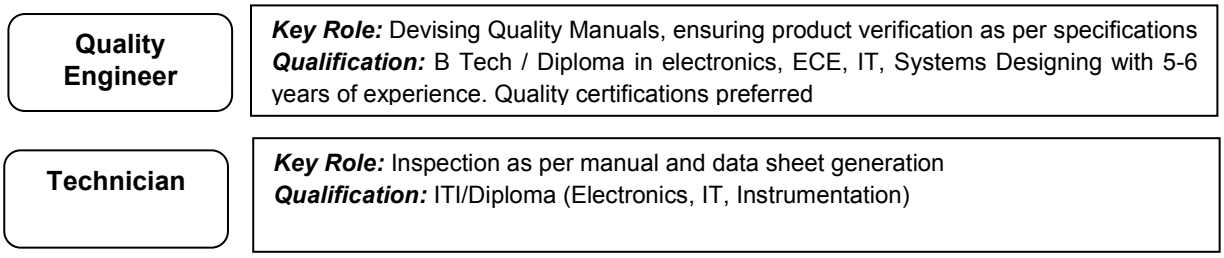
- Ability to update technical knowledge about latest technology and applied research innovations proficiency in prototype designing/testing for IT Hardware – VLSI and embedded technologies
- Database Management and record keeping skills
- Ability to handle unstructured and repetitive work due to large number of iterations involved in the process

- Problem solving attitude and flair for innovation keeping in mind the desired outcome
- Knowledge of quality certifications (such as six sigma, ISO, etc) so that the new product/prototype complies with safety standards and specifications.

5.4 Skill requirements in Quality Assurance function

In quality assurance/quality check function, the key roles are those of Technician and Quality Engineer. The key activities performed and the qualifications required for each of the level are as follows:

Figure 16 : Roles in Quality Assurance function and qualifications required



Quality check is an important function for all the companies in the IT Hardware and Electronics Manufacturing Industry. There is however limited hierarchy in the structure for this role. A few large companies in telecom equipment and consumer electronics industries have one more level above quality engineers to oversee the complete function, with engineers and technicians performing product verification at two levels.

The functional and soft skills required at each of the above levels are as follows:

Quality Engineers: The typical functional and soft skills required at this level include:

- Awareness about latest developments in quality and process improvements areas and preparing quality manuals in accordance
- Ability to supervise and lead inspection process
- Ability to understand the quality requirement of the clients and train the technicians as per own quality standards or those of OEM (in case of contract manufacturers)
- Strong goal orientation.

Technicians: A person at this level is expected to undertake the inspection as per quality manual so as defects in final product to clients can be minimised. The typical skills required at this level include:

- Understanding of the quality assurance process and ability to follow the inspection manual properly

- High level of diligence and aptitude for repetitive and monotonous jobs
- Ability to identify the deviations
- Meticulous in record-keeping and data management
- Analytical skills to analyse the data and identify the trends in inspection results.

5.5 Skill requirements in After-Sales Service function

After-sales support is a key function in the IT Hardware and Electronics Manufacturing Industry, especially in consumer facing sectors. The key activities, qualifications and skills required for after-sales support roles are explained below:

Service Support Executives: A Service support executive is expected to be aware about the functionality of various products and train the repair mechanics, apart from providing guidance/undertaking more critical repair jobs. These mechanics are generally Diploma holders in Electronics, IT systems, Instrumentation and Electrical engineering. The typical skills required at this level include:

- Technical knowledge about product and technologies
- Ability to motivate and train repair mechanics
- Ability to address customer complaints in the most effective and efficient way
- Good communication skills.

Repair Mechanics: A person at this level is expected to undertake the repair work at various service centres of the company, which could be company owned or franchised. These mechanics are generally ITI pass-outs in Electronics, IT systems, Instrumentation and Electrical trades. The typical skills required at this level include:

- Ability to follow the instructions manual
- Trouble shooting skills
- Ability to handle tools and equipments
- Knowledge about product and its configuration.

5.6 Skill requirements in Software Development function

Software Development is a critical function particularly for telecom equipment manufacturers. The skill requirements at various levels are as follows:

Project Director: A Project Director is responsible for strategising the software development initiatives, budgeting, defining the scope and supervising execution for software development. The desired qualification is B.Tech and MBA with 8-10 years experience in IT/Telecom and System Integration. The typical skills required at this level include:

- Good networking skills
- Team management skills
- Ability to provide directions to the team for operational planning and execution
- Knowledge about the latest developments in the industry
- Sound costing and budgeting skills.

Program Manager: A person at this level is expected to manage the project in the most economic and efficient way through detailed planning. These Program Managers are B Tech/M Tech in Electronics, IT Systems, Instrumentation or Electrical with 7-8 years experience. The typical skills required at this level include:

- Ability to plan the project and monitor the progress on a regular basis
- Ability to train the team and ensure completion within set deadlines
- Should be resourceful and an effective team leader
- Good communication skills.

Software Engineer: A person at this level is responsible for developing the software and testing the software programmes as per requirements. Software Engineers are B Tech/M Tech in Electronics, ECE, Computer Science with 3-4 years experience in software development. The typical skills required at this level include :

- Knowledge about programming languages such as UNIX/ Java, C/C+
- Analytical skills
- Strong goal orientation
- Communication skills.

Generic and sector specific *skill gaps* are presented in the following section.

6. Key skill gaps in manpower employed

There is a severe shortage of trained manpower in the industry across levels. Though the shortage seems more acute in the manufacturing and sales function, it is equally critical for the research and development initiatives where there is virtual non-existence of researchers. India's education infrastructure produces one of the highest numbers of engineering graduates in the world. However, the industry has to expend significant efforts on improving the skills of the people at various levels.

The discussions with industry players across the country indicate major skill gaps at all levels in the core functions of production, sales, service, quality and Design and Development.

This section presents the skill gaps in the IT Hardware and Electronics Manufacturing Industry. *We have detailed the various skill gaps primarily based on our interactions with the stakeholders.* The skill gaps have been detailed at each functional level. *For each function, there will be certain general skill gaps common across various sectors. At the same time, there will be certain skill gaps which are sector specific.* Sector specific skill gaps have been illustrated when the proportion of workforce employed in the function under consideration for a specific sector is significant.

This section details *both generic skill gaps as well as sector specific skill gaps* at each functional level.

6.1 Skill gaps in Production Function

Production function employs the maximum manpower across sectors, except IT hardware where service related manpower has the highest share in total manpower in a company.

General skill gaps in Production function

Helper level: The helper level people generally lack the industrial culture to work on the shop floor. They are provided with short duration training on behavioural aspects as their job does not involve any technical skills, but still gaps remain.

The key skill gaps at this level are as follows:

- High absenteeism, lack of punctuality
- Lack of discipline at workplace for adhering to production norms

- Inability to identify deviations in material and inform the operators/supervisors
- Insufficient awareness of health and safety standards, despite being educated about the same.

Operator/Technician level: Currently there is a shortage of operator level people in production and quality function. Productivity at this level remains fairly low because of the lower order skill sets and inability of the operators to handle variations from normal functioning.

The key skill gaps are as follows:

- Inability to understand material variation and take corrective action or escalate the issue so that wastages can be minimised
- Incapable of identifying defects at any particular point in the production line and rectifying the same on time
- Lack of machine handling ability and knowledge of latest technologies
- Insufficient orientation to learn - Operators do not make an attempt to understand new processes and need handholding for a much longer period than required
- Inability to understand instructions and product designs completely
- Quality technicians lack the computer proficiency and data management skills, the quality manual is not referred to diligently in few cases. Most of the people lack understanding of latest quality concepts and techniques.

Supervisor level: At this level in the production function, the key gap is in terms of insufficient knowledge of the techniques of the production process as well as people management skills. As a result, a Supervisor is unable to manage the production environment successfully.

The key skill gaps at this level are

- Inability to control wastage (of material as well as man-hours) effectively
- Inability to monitor the production metrics (such as hourly production rate variation) and identify the reasons for shortfall so that the same can be avoided
- Language barriers in some cases as diploma holders/engineers from other geographic locations are not well versed with English and most of the production manuals are in English
- Lack of communication skills, which poses a problem in mentoring the operators and giving them clearly understandable instructions
- Supervisors are non-conversant with modern production techniques such as JIT, TPM.

Shift/ Quality Engineer: At this level in the production/quality function, people typically have 6-8 years experience. At this level the key skill gap is mainly in terms of soft skills. These include:

- Inability to keep the team motivated and manage their expectations
- Inability to involve subordinates or take their feedback in decision making process
- Poor capability to prepare inspection manuals and supervise the inspection process
- Lack the enthusiasm to organise quality/system improvement training and inculcate a culture of quality consciousness among workers.

In the overall Production function, there is a general lack of understanding of concepts of

- Soldering – manual and automatic
- Shop floor concepts, clean room
- Equipment identification and handling
- Quality and safety issues.

This is especially true at the operator level.

Sector specific skill gaps in Production function

Consumer Electronics: In this sector, roughly 50% of the workforce is engaged in the production function. Specific skill gaps are:

- Insufficient knowledge about the manufacturing of new products in the sector (Flat TVs, LCD TVs, Plasma TVs), insufficient knowledge of PCB assembly/population
- Insufficient understanding of components being used in the latest products in the sector, material management and reduction of rejection in the production of these new products
- Shortage of technically qualified people for quality audit function as well as machine operators and maintenance technicians of Surface Mounted Technology (SMT)/Auto Insertion. Skilled manpower for handling SMT/auto insertion machines are expected to be a severe shortage.

Components: In the case of manufacturing of components, more than 80% of the workforce is involved in the production process, including quality inspection. The key skill gaps related to manufacturing of components are as follows:

- At operator level, current manpower faces issues in understanding process charts, material variation and machine operations
- Lack of knowledge of PLC programming and Robotic machinery maintenance
- Operators involved in the inspection process lack the capability to carry out this function as per the

manual

- Insufficient computer proficiency and data management training
- There is in general a shortage of maintenance technicians/ electricians/ fitters for handling boiler, machine panels and air conditioning systems
- At Line in-charge/Supervisor level, key skill gaps are lack of understanding of concepts of productivity improvement, line balancing, time and motion studies, knowledge of production metrics like hourly production rate variation, inventory management.

IT related hardware: Key skill gaps in this sector are in the case of Engineers employed and to some extent in ITI pass-outs who are hired as Assemblers. The skill gaps are as follows:

- In case of Engineers, lack of latest product and technology knowledge, insufficient skills for execution of product development, insufficient knowledge of production line processes like optimal kitting of components for assembly and mass production practices, including line error minimisation
- In case of ITI pass outs (mainly those specialising in the Electronics trade), who take up assembly based on circuit charts and diagrams, ability to understand processes in assembly is a major skill gap.

6.2 Skill gaps in Sales Function

General skill gaps in Sales function

Sales Executive level: The sales executive generally lacks the understanding of consumer behaviour and buying decision making process. They are provided short term trainings on improving inter-personal skills, communication abilities and products of the company. The key skill gaps in the industry are as follows:

- Lack of understanding of the products being sold (own as well as those of competitors), which results in targeting the wrong customers or not being able to fully convince the customers about product features and functionalities
- Inadequate communication skills, especially those people who only have an engineering background
- Inability to keep proper MIS records.

Senior Sales Executive level: At this level people lack negotiation and deal closure abilities. The key skill gaps in the industry are as follows:

- Inability to prepare/make an effective sales pitch by matching the product functionalities with customer requirements
- Lack of understanding of customer needs and trends in the industry
- Inadequate negotiation skills and proactive attitude to actively pursue and close deals.

Area/Territory Manager level: These people are expected to maintain good relationships with channel partners and train their own field staff. The key skill gaps in the industry are as follows:

- Inability to mentor/train the field staff in terms of generating and closing the deals
- Lack the enthusiasm to assist the field staff for marketing calls
- Lack of leadership skills and relationship management skills
- Inadequate planning skills for event-based marketing in association with channel partners
- Lack of focus on product profitability as people put more emphasis on meeting the sales target with little or no attention on the profitability aspect which impacts the overall performance.

Sector specific skill gaps in Sales function

Consumer Electronics: This sector has more than 25% of its workforce involved in the Sales function as it requires high level of customer interaction with the end user. Key skill gaps for Sales personnel employed in this sector are:

- Insufficient understanding of the financial aspects of business - cost structure of the trade channels, margins involved along the value chain and the consequent discounting strategy to be used
- Ineffective sales force management
- Insufficient coordination with service team to fulfil service commitments and annual maintenance contracts
- Insufficient exposure to understanding customer requirements.

IT related hardware: This sector has roughly 25% of its workforce employed in the Sales function. Key skill gaps in sales personnel are:

- Insufficient understanding of the dynamics of the customer organisation's functioning and their business requirements for IT related hardware (relating business requirements to technology)
- Inability to interact confidently with the higher echelons of the customer's organization about their needs and how to fulfil them.

6.3 Skill gaps in Design and Development Function

General skill gaps in Design and Development function

Design Engineer: These personnel require highly specialised skill sets and an orientation towards research. The key skill gaps in the industry are as follows:

- Lack of understanding of latest technologies in product proto-typing and inability to upgrade the technical knowledge
- Theoretical concepts of Electronics/Embedded Software weak
- Insufficient exposure to practical training
- Testing and validation skills are not in line with industry requirements
- Lack of problem solving attitude, innovation and creativity.

Project Lead: These people are well experienced professionals with good-track record and aptitude for research. In general there is a shortage of scientists and research heads as there is limited infrastructure for training and development of research people. The key skill gaps are:

- Lack of ability to communicate effectively with concept development team
- Insufficient project management and integration skills
- Insufficient exposure to cost optimisation, resource management and productivity improvement.

Sector specific skill gaps in Design and Development function

Semi conductors: There is expected to be a huge shortage of people having theoretical knowledge of Electronics - Embedded Software and people qualified for VLSI design. At senior levels, the skill gaps are mainly related to insufficient project management and integration skills, productivity improvement, team building and people management.

IT Hardware: A key skill gap is the lack of interest in Application Research.

6.4 Skill gaps in Software Development

For software development, skilled manpower is mainly required in IT hardware and telecom equipment sectors as they have to ensure seamless integration of hardware with software.

General skill gaps in Software Development

Key skill gaps in this function are

- Lack of understanding of programming languages such as C++/Java and Symbian technology platform
- Insufficient analytical skills and communication skills to scope out the customer need
- Insufficient skills for project management and resource management.

Sector specific skill gaps in Software Development

IT hardware: There is insufficient knowledge of algorithm engineering and verification of algorithm results during the Development phase. Developing the enabling software for hardware to function is a major skill gap.

6.5 Skill gaps in After-Sales Service

After-sales service is a critical function in the case of Consumer Electronics, mobile handsets and computers.

Skill gaps in After-Sales Service

There is expected to be a shortage of people in the area of maintenance and repair of consumer electronics (mainly new products like Flat TVs, LCD), communication equipment (mainly mobile handsets) and home computers.

Senior Service Technician: The key skill gaps are:

- Lack of ability to handle complex issues, especially related to customer complaints and expectations
- Inability to train mechanics for repair jobs
- Product knowledge is not upto the required level
- Diagnostic skills are a gap
- In the case of computers, knowledge of sub-assembly is a major gap
- Knowledge of system integration, mainly for Government and Enterprises, including Network Design, is a major skill gap.

Repair Mechanics: The key skill gaps in the industry are as follows:

- Lack of practical orientation and equipment handling ability, hence a lot of time has to be spent on in-house training to handle newer operating tools and equipment
- Great deal of handholding is needed as they lack logical thinking and problem solving attitude
- Insufficient skills to handle customer grievances and assure customer satisfaction, inability to take up reporting in an effective manner.

Sector specific skill gaps in After-Sales Service

IT Hardware: The key skill gaps are in the areas of:

- Understanding control circuitry and power supply
- Trouble shooting
- LCD Panels
- Modular units
- Customer interaction
- L1 and L2 level repairs.

Telecom Equipment: The key skill gaps, especially in servicing mobile handsets, are:

- Fault identification
- Customer interaction
- Board level repair
- Signal testing and signature reading
- L1 and L2 repairs.

It should be further noted that, at an industry level, in addition to the issues mentioned above, the following table summarises the factors that influences the shortage of human resources.

Table 13 : Summary of factors influencing shortage of human resources

Function	Summary of factors influencing shortages of human resources
Production	Lack of adequately skilled human resources at entry level and shortage of experienced personnel at higher levels. This has a cascading effect on salaries.
Sales	While skill shortages exist, there is the additional factor of competition from other industries (such as retail, other consumer goods) for the same talent pool, which also results in attrition to other industries and inflated salaries.
Design and Development	Shortage of adequately skilled human resources (those with requisite design skills).
Software Development (for Electronics)	While skill shortages exist, there is the additional factor of competition from the IT industry.
After-sales service support	Large demand for servicing skills which are fairly interchangeable within the industry, resulting in flight of talent within sectors.

Source: IMaCS discussions during the primary survey

While shortage of human resources is the major factor prevalent in Production, and Design and Development functions, higher salaries and attrition are the major factors prevalent in shortages behind sales and software development.

7. Current education infrastructure and gaps therein

7.1 Overview of education infrastructure

Design focussed companies typically recruit engineers from prestigious engineering institutes like IITs, IISc and Tier I regional engineering colleges such as BITS Pilani. Companies focussed on manufacturing as well as those recruiting for low end technical jobs, hire from the Regional Engineering Colleges (Tier II) across the country. In case of low end manufacturing, having very little focus on design, recruitment is typically done through referrals and Tier III (including private) engineering colleges and polytechnic/ITIs from the nearby region.

Usually companies prefer to hire engineers/diploma holders/ITI students from the local population at the institutes located in the vicinity of the company, so that their attrition is lower. For example Flextronics in Chennai has tied up with Anna University and other reputed private engineering colleges in the same region. Likewise, in the northern region, especially in industrial locations in Punjab recruitment is done from Thapar Institute of Engineering and Technology, Patiala.

The key institutes from where the industry recruits are:

- Tier I Engineering colleges: All IITs, Indian Institute of Science, Bengaluru, BITS Pilani
- Tier II Engineering colleges: Top 20 Regional Engineering Colleges primarily from State Universities, such as College of Engineering (Anna University)
- Tier III Engineering colleges: Private engineering colleges
- Local polytechnics
- ITIs/ITCs

Management graduates are sourced from the top ten management Institutes of India (including all IIMs), other leading b-schools, experience professionals, by high end companies like Motorola and from private management institutes and/or university graduates by low end companies through job portals and referrals.

7.2 Key issues related to education infrastructure

Most of the educational institutes face issues that are related to insufficient infrastructure and quality of teaching/practical training.

It should be noted the issues highlighted in the following sections are based on interactions with various stakeholders in the industry and institutes during our primary survey.

The key issues are:

- ***Insufficient number of faculty members:*** The educational institutes (with the exception of Tier I institutes) face an issue of insufficient number of staff members and technicians to train students. For example, in a leading engineering college located in Bengaluru, one of the key hubs for IT Hardware and Electronics Manufacturing Industry, the sanctioned number of faculty members is around 105 for the courses being offered, but currently there are 87 permanent faculty members, with most of the vacant positions in Information and Computer Science section. Barring a few Government institutes, there is always a procedural delay for fulfilling the shortfall in the teaching faculty. Institutes increase the intake of students only, without increasing the count of faculty. This, coupled with the added responsibilities of managing placement activity, leaves lesser time for the faculty to interact with the industry or undertake higher studies or advanced training courses to keep themselves updated on the latest technology trends. This leaves a wider gap in the quality of teaching offered and the industry expectations.

  ITIs in the country face a perennial problem of insufficient number of instructors. The available instructors are rotated across trades for some of which they do not have adequate knowledge. Though faculty members are recruited on contract, compensation terms are not very favourable which has severely affected the quality of such instructors in certain ITIs.

  The quality of trainers becomes a major issue in ITIs, as in many cases those who have just pass-out from institutes are employed with little or no practical/industry exposure. Furthermore, certain regions are faced by funding constraints from the state and therefore prefer to employ on contract basis rather than full time basis. A teaching job at the ITI is viewed as a stop-gap arrangement by contract faculty and the effect is that the overall quality of training suffers.

- ***Inadequate infrastructure:*** The practical training infrastructure is very old in these institutes and hence outdated. In certain cases where new machines are acquired, concerned technicians to provide training and technology inputs are unavailable. Infrastructure like labs/workshops falls short of industry expectations. For ITIs/Polytechnics the situation assumes greater significance as the course focus is more on industrial training. In many of the ITIs, funds for students training are not adequate as many a times students re-work on used materials and practical trainings are reduced for lack of raw materials. Certain ITIs even lack basic infrastructure required in labs.

- ***Lack of Industry interface/practical training:*** The educational institutes are not adequately oriented towards industry requirements. Even the faculty members have insufficient interaction with the industry and are thus not in sync with industry requirements.

- ***Delays in curriculum changes:*** The curriculum changes in the courses being offered require approval from the concerned technical education authorities. This is a very time consuming process. Till the time formal approval comes, faculty members in many cases try to teach new developments as out of subject classes but there are several shortcomings in this approach. The lack of market orientation and the inflexibility in making even minor changes to the curriculum is a major impediment in meeting the industry's needs.

  Barring a few autonomous educational institutes such as Jamia Millia Islamia, which can affect changes in the curriculum as approved by their own academic council, there are considerable delays and lack of industry orientation in the curriculum being offered at present. For example, companies operating in the high end of the value chain like Cadence and ST Microelectronics, require courses/training programmes in VLSI, and design testing and validation, but this has still not been addressed by any educational institute in a major way.

- ***Lack of fluency in English language:*** Students passing out from most ITIs, polytechnics and Tier 3 engineering colleges have very poor knowledge of spoken as well as written English. In many of the institutes from where these students come from, the language of communication is the regional language and not English even though the books related to their courses are in English. The students already have a weak background in the language because of insufficient coverage in school. This creates a problem for them when they have to refer to instructions or manuals on the shop floor that are usually in English.

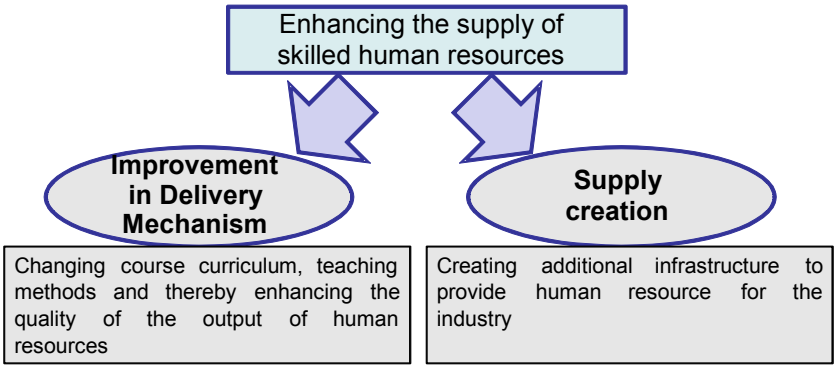
8. Recommendations

Based on the feedback of the industry and skill gaps identified in the IT Hardware and Electronics Manufacturing Industry, our recommendations are designed to address the following key questions

- What can be done by the various stakeholders, viz. Government, Industry and Educational institutions, to improve the employability of the human resources?
- What should be the implementation mechanism to drive the skill development initiatives?
- How do we fund various skill development initiatives?

The broad framework for skill development has been designed to ensure the optimum utilisation of existing infrastructure and creation of new infrastructure on need basis. Thus, MAIT recommends the following skill development framework for improvement of skills at various levels:

Figure 17 : Skill Development Approach



To achieve effective implementation of skill development initiatives, co-ordinated efforts are required from all stakeholders for improving the effectiveness of existing education infrastructure and creation of new infrastructure. The implementation mechanism of the above shown framework has detailed out the respective roles and responsibilities of each stakeholder. The various initiatives to be taken require close co-ordination between various stakeholders such as Government, Education Institutes and Industry.

Broadly, MAIT recommendations are targeted at the following levels:

I. Introducing short term courses and opening training institutes in after-sales service support
II. Introducing short term courses to train people for sales function
III. Inculcating simple assembly/related skills and shop floor ethics at grass root level
IV. Improving skills for contract manufacturing and assembly operations
V. Creating appropriate infrastructure to train people at operator level

VI. Opening Engineering Finishing Schools for technical graduates

VII. Capacity creation and curriculum updation in Technical Education

VIII. National/Regional Centres of Excellence for Design and Development skills

IX. Imparting specialised training for emerging high technology manufacturing

Our recommendations are also summarised in an implementation road map, where specific steps and stakeholder action items and responsibilities are detailed. The implementation road map will help answer the questions, 'What are the actionable items?', and 'Who should be doing what?' We have identified key stakeholders in the Government and Industry to take the lead initiative in rolling out the above initiatives.

Table 14 : Primary stakeholders responsible for various recommendations

Recommendation	Primary stakeholder responsible for implementation
Introducing short term courses in after-sales support	Government – Director General of Employment and Training (DGET)
Introducing short term courses for training people in sales	Government – Director General of Employment and Training (DGET)
Inculcating simple assembly/related skills and shop floor ethics at grass root level	Government – Director General of Employment and Training (DGET)
Improving skills for contract manufacturing and assembly operations	Large industries, OEMs, industry associations
Creating appropriate infrastructure to train people at operator level	
- *Capacity addition at ITIs*	Government – Director General of Employment and Training (DGET)
- *Enhancing curriculum of ITIs*	Government – Director General of Employment and Training (DGET)
- *Creating quasi shop floors*	Government – Director General of Employment and Training (DGET)
- *Enhancing functioning of Placement Cells*	Institutes
Opening Engineering Finishing Schools for technical graduates	Industry and industry associations
Capacity addition and curriculum updation in Technical Education	
- *Capacity addition in Research – Doctoral and Post Graduation*	Government - Department of Higher and Technical Education/Ministry of Human Resource Development (MHRD)
- *Capacity addition and curriculum*	Government - Department of Higher and Technical

updation in Electronics and related areas of Engineering	Education/Ministry of Human Resource Development (MHRD)
- *Capacity addition and curriculum updation in Diploma Polytechnics in Electronics and related areas*	Government - Department of Higher and Technical Education/Ministry of Human Resource Development (MHRD)
National/Regional Centres of Excellence for Design and Development skills	Ministry of Communications and IT – Department of Information Technology
Imparting specialised training for high technology manufacturing	
- *Regional High-Tech Training Centres*	Ministry of Communications and IT – Department of Information Technology
- *Curriculum updation in Engineering Colleges*	Ministry of Human Resource Development (MHRD) – Department of Higher and Technical Education
- *Train the trainer initiatives*	Industry and industry associations

While the primary stakeholder responsible for various initiatives has been mentioned above, each of the initiatives involve interaction and coordination between various stakeholders – Government, industry, and institutes. The roles of each stakeholder for action items under various initiatives are detailed in the implementation road map.

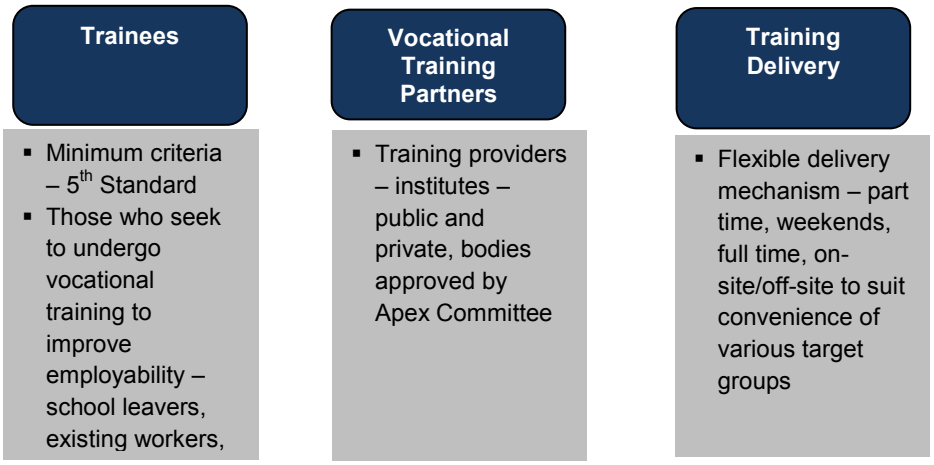
I. Introducing short term courses and opening training institutes for after-sales service support

After-sales service is the most critical function in the IT Hardware as well as Telecom sectors. It is an important function in other sectors such as consumer electronics. It requires significant consumer interaction. The service support team is generally staffed predominantly by Diploma holders and ITI trained personnel, as well as some $10^{th}/12^{th}$ students who are trained. Going forward there is expected to be a shortage of people to handle maintenance/repair for attending complaints and catering to annual maintenance contracts (AMC).

Proposed Training

A strong vocational training system needs to be developed to provide training in this area and can be developed under the framework of the existing Modular Employable Skills (MES) scheme of the Directorate General of Employment and Training (DGET), which provides for modular, specialised, short duration training programmes. The focus of the MES is on securing 'minimal skill sets' leading to gainful employment. The following indicates the functioning of the MES:

Figure 18 : Overview of the Modular Employable Scheme (MES) of DGET



Under the MES, school-leavers, existing workers and existing ITI pass-outs undergo vocational training to upgrade their skills. The training is provided by independent training providers, Government, or other approved bodies. The delivery mechanism is flexible and the training is provided even on weekends. The assessment can be done at the convenience of the employee and the assessor (who can be even an industry representative). The certification for this programme is provided by the NCVT. The DGET calls for participation from Industry in forecasting employment trends, developing curriculum, providing training, certification, and placement.

Sectors and locations to be targeted by leveraging the existing MES scheme

Service support/after-sales support has emerged as an important area the industry, especially from the perspective of employment generation capability. A large proportion of the incremental human resource requirement in service support occurs in the areas of Computers (about 2 lakh persons), Consumer Electronics (about 32,000 persons), and Telecom Equipment (80,000 persons). Hence, we propose that modular courses under MES scheme be introduced in these specific areas to complement the existing outturn from Diploma and ITI personnel. Furthermore, a large proportion of these requirements would arise at the preliminary/basic service support level (referred to as L1 and L2 in the industry), which can be catered to under this scheme. This will enable diploma and ITI holders from other related specialisations to quickly acquire such skills, and also enable those educated upto secondary education (10^{th} standard) to acquire skills in these areas. The course areas can be developed for:

- Servicing of Consumer Electronics/Consumer Durables – Separate modules need to be created for different appliances. Focus needs to be given in particular to flat CTV, which is driving growth in the Consumer Electronics segment, and should also include LCD TV and plasma TV as well as rectification of faults in DTH. Course content to also include:

- TV servicing (including flat TVs, LCD and plasma TVs), servicing of car radios, radio and CD/VCD/DVD players
- Servicing of Air Conditioners, Heaters, and Coolers.

- Servicing of IT Hardware – Separate modules need to be developed for computers, laptops, networking equipment. Course content to include:
  - Wiring and installation of LAN equipment
  - Basic fault finding and reporting of faults in Switches, Routers, and other networking equipment
  - Basic fault finding in computers – desktops and laptops, such pertaining to Hard Disk Drives, CD, Motherboard, RAM, SMPS
  - Assembly and installation of spares.

Box 1: Illustrative course content for after-sales service support

For the pass-outs from ITIs, the course content should be for the following

- Introduction to new products in the industry and technology trends
- Hands-on experience on latest tools and equipment used in the sectors under consideration
- Repair and maintenance of latest equipment, safety precautions to be taken
- In case of IT hardware in particular, upgrading computing devices, installing operating systems and application packages, handling common peripherals, installing network environment, handling multimedia projectors and related devices, LAN connections, Internet connections
- Soft skills to handle customer grievances, problem solving skills
- Importance of compliance to policies and standards of companies related to service

For Diploma holders, the course content should include

- Introduction to new products in the industry and technology trends
- Hands-on experience on latest tools and equipment used in the sectors under consideration
- Repair and maintenance of latest equipment, safety precautions to be taken
- Concept of Customer Relationship Management (CRM) and CRM strategies of companies
- Customer conflict and Complaints management
- Understanding and designing customer satisfaction surveys

Note: The above content should be made available in different sector areas outlined in the narrative prior to this Box

- Servicing of Telecom Equipment – Separate modules need to be developed for mobile handsets and communication equipment. Course content to include:
    - Basic fault finding of GSM and CDMA handsets
    - Understanding wireless LAN systems and troubleshooting, including Bluetooth and WiMAX
    - Basic installation and fault finding of wireless and wired networking equipment at customer premises.

In addition to the above, the course content should also cover 'softer' areas such as customer interaction, service report filling, and service reporting to line managers.

The Government should encourage the setting up of **Sales and Service Training Institutes (SSTI)** which needs to be opened across the major consumption centres across the country as these locations have the maximum number of service centres coming up. The SSTIs could be set up by private training providers and would provide training modelled on the lines of the MES scheme and in specific areas identified above. They would provide training in both servicing of equipments and sales areas also (to be covered in subsequent section).

Roles and Responsibilities in Delivery

This scheme can be used effectively to generate skilled workforce in after-sales service support for industry through short duration, modular, vocational training. The following are the proposed roles and responsibilities of various stakeholders.

Industry – The industry should promote its existing informally trained workforce to actively participate in such training programmes. It should also build awareness among the aspiring workforce of the career prospects available in the sector and how the opportunities are further advanced when the aspiring workforce is exposed to such training. Industry should also communicate the advantages of certification which formalises the knowledge of skills. Private operators should be encouraged to come forward to build capacity to provide training in these areas.

Government – The Government should build awareness in the workforce and the aspiring employees about the existence of such training programmes. The development and approval of new courses should be facilitated and the Government should actively work with industry in this regard.

Institutes and Training Providers – ITI/ITCs can also provide such training, in addition to Government, authorised, and private training providers. All those involved in providing such training should interface with the industry for assistance in training delivery through interaction, as well as providing support in the placement of such trainees.

Certification – Courses conducted under the MES framework will be certified by the Government/NCVT. For courses run by private operators through SSTIs, common certification criteria should be evolved by the industry which is acceptable across segments. Such a certification process would improve the employability of the students passing out of SSTIs. At the same time, it would also provide a guarantee to the employing company regarding the capability of the student they are employing. Such a certification mechanism is being adopted by NASSCOM for the IT industry.

Further, it should be noted that existing schemes of the Government, such as the Multiple Entry – Multiple Exit mode under the Centre of Excellence schemes for ITIs should also be used by Industry effectively and awareness should be built in the workforce to actively participate in these schemes.

As outlined in the implementation road map, the primary stakeholder responsible for this initiative is the DGET.

Implementation Road Map

The implementation road map is presented in the table below with stakeholder action points.

Table 15 : Implementation road map for short term courses in service support

Recommendation and Primary stakeholder responsible	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
Recommendation - *Short term courses to train people in service support* Primary	Diploma and ITIs students trained in related areas, extending upto training for 10th/12th students	Primarily enabling diploma and ITI students trained in related areas to quickly acquire service support specific skills.	Courses should be introduced as outlined above (see Box 1) in service support in different sectors	Government (DGET) to formulate curriculum (as outlined above) with inputs from industry and

Recommendation and Primary stakeholder responsible	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
stakeholder responsible for implementation: *Government – Director General of Employment and Training (DGET)*		Also serve as a channel for interested 10th/12th students who are taking up service support jobs to acquire formalised training.		institutes
			Awareness should be built and employees should be encouraged to undertake such courses	Industry, industry associations (such as MAIT, ELCINA, TEMA, CEHA, and others), to build awareness in prospective employees. Government to support this initiative of awareness building
			Delivery - Courses should be made available under the MES scheme	Government (DGET)
			Delivery - Courses should also be made available at SSTIs	Private Operators should be encouraged to offer service support courses in SSTIs which they own and operate
			Testing and Certification	For Government (DGET) run courses under MES, the certification will be done by NCVT (as is the current practise). For courses run by private operators in SSTIs, a common certification mechanism to be

Recommendation and Primary stakeholder responsible	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
				evolved by industry/industry associations which is acceptable across the industry. Based on this mechanism, testing and certification would be performed or overseen/supervised by an industry accepted body.

II. Introducing short term courses to train people for sales

The consumer electronics sector and IT related hardware have a significant proportion of personnel employed in sales, where business-to-consumer selling is important and high level of customer interaction is required with the end user.

The key skill gaps in the manpower employed in this function is their insufficient understanding of the financial aspects of business (cost structure of the trade channels, margins involved along the value chain and the consequent discounting strategy to be used), insufficient coordination with service team and insufficient exposure to understanding customer requirements.

Proposed Training

Courses maybe offered under the MES scheme for those already employed in the industry and wanting to undergo training to hone their selling skills. These courses would incorporate detailed understanding of financial aspects of business, marketing and sales force management. These courses can be offered at the SSTIs (discussed in the earlier section) also.

Box 2: Illustrative Course content for Sales

Short term modular course for Sales function

- Basic financial analysis (understanding of concepts of profitability, cost structure of businesses etc)
- Tax structure
- Business culture
- Marketing
- Sales force management
- People management
- Consumer behaviour

As outlined in the implementation road map, the primary stakeholder responsible for this initiative is the DGET.

Implementation Road Map

The implementation road map is presented in the table below with stakeholder action points.

Table 16 : Implementation road map for short term courses in sales

Recommendation and Primary stakeholder responsible	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
Recommendation: ***Short term courses to train people in sales***	Large number of persons right from 10^{th}/12^{th}, Diplomas, science graduates engaged in sales	Enabling those making a transition to sales of IT Hardware and Electronics to acquire necessary skill sets	Courses should be introduced as outlined above (see Box 2) in Sales	Government (DGET) to formulate curriculum (as outlined above) with inputs from industry and institutes
Primary stakeholder responsible for implementation: *Government – Director General of Employment and Training (DGET)*			Awareness should be built and employees should be encouraged to undertake such courses	Industry, industry associations such as MAIT, ELCINA, TEMA, CEHA, and others to build awareness in sales force. Government (DGET) to support this initiative

Recommendation and Primary stakeholder responsible	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
				of awareness building
			Delivery - Courses should be made available under the MES	Government (DGET)
			Delivery - Courses should also be made available at SSTIs	Private Operators should be encouraged to offer Sales specific courses in SSTIs which they own and operate
			Testing and Certification	For Government (DGET) run courses under MES, the certification will be done by NCVT. For courses run by private operators in SSTIs, a common certification mechanism to be evolved by industry/industry associations which is acceptable across the industry.

III. Inculcating simple assembly/related skills and shop floor ethics at grass root level

Grass root level training initiative should be aimed at imparting basic and advanced training to unskilled workers to enable them to take up jobs in industries in a structured manner. The target group includes school drop-outs, 10^{th}/12^{th} pass-outs/drop-outs, and casual labourers in key production clusters. This group is engaged in simple assembly/related activities such as helper level functions. The skill gap in this group is generally pertains to:

- Lack of understanding of shop floor work practices
- Lack of any knowledge whatsoever of electronics and simple components.

While this group does not engage in operator related skills, providing basic training in shop floor practices will help increase productivity and reliability. This initiative will have two levels - Level 1 focussed on basic training programme and Level 2 focussed on advanced training programme. The course content for this training programme is outlined in Box 3.

Delivery Mechanism

The courses shall be modular and delivered through the existing MES framework of the MES under the DGET. The existing education infrastructure should be leveraged to train the people on the above skills. ITIs and polytechnics in the production clusters can be used as training grounds after normal work hours. This shall require the involvement of both the Government and private sector. The Government shall extend the support by way of providing the funds for grass root level skill training and educating the workers about the initiative through involvement of NGO and labour unions at the block levels in specific production clusters. The private sector shall have to play a more proactive role in terms of supporting the grass root level skill initiative by communicating the industry's skill requirements and conducting the training through people from within the industry (companies to make available some of their people beyond their day-to-day production activities) as well as industry associations, retired teachers, teachers working on contract with education institutes. In order to make the training effective and ensure its acceptance within the industry, the skills of the trainees should be certified by NCVT.

Funding Scheme

The Government could subsidise the cost of training as the target workforce essentially comprises of daily wage earners with limited means to fund their training. The industry should mobilise resources to provide trainers as far as possible. The Government may also consider incentivising the trainees by offering them the prescribed minimum daily wage in the specific location for the period of training. The total cost of training per person would work out to roughly Rs. 6,000-7,000, which includes the cost of trainers, reimbursement of wages and fee for course content.

Box 3: Illustrative course content for inculcating simple assembly/related skills and shop floor ethics at grass root level

Level 1. Basic Training Programme: This programme is aimed at imparting basic training to unskilled people to create awareness about industry practices in general and provide basic skills for employment. A month long training on general introduction to work culture at the shop floor should be conducted to imbibe work discipline with respect to

- Basic manufacturing skills
- Safety norms
- Meeting pollution control laws, etc.
- Punctuality
- Adherence to cleanliness norms.

Level 2. Advanced Training Programme: This programme is aimed at imparting advanced training to people who have undergone basic training programme (Level 1) and unskilled people from the industry with an objective of developing industry specific skills.

This shall comprise of month long training on industry specific skills targeted for specific production activities that require minimum technical knowledge.

The key skills that can be targeted are

- Drilling, rough turning and machining
- Identification of simple components involved in assembly
- Basic operations in the electronics shop floor and basic activities like sub assembly population
- Maintenance of tools and equipment
- Assembling of electronics products, packing, etc.

As outlined in the implementation road map, the primary stakeholder responsible for this initiative is the DGET.

Implementation Road Map

The implementation road map is presented in the table below with stakeholder action points.

Table 17 : Implementation road map for inculcating simple assembly/related skills and shop floor ethics at grass roots level

Recommendation and Primary stakeholder responsible	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
Recommendation: ***Inculcating simple assembly/related skills and shop floor ethics at grass roots level*** Primary stakeholder responsible for implementation: *Government – Director General of Employment and Training (DGET)*	Helpers, daily wage earners, those moving from school to work, such as school drop outs, as well as those moving to work from 10th and 12th standards	Enabling such persons entering into formal/organised work environments for the first time with basic work related skill sets	A nodal agency will oversee the training by coordinating with local workforce, developing training programme, sourcing trainers, pay for training, and oversee delivery	Government (DGET) to appoint the nodal agency and play the lead role in coordinating with other stakeholders. The Government (Ministry of Labour and Employment) could subsidise the cost of training as the target workforce essentially comprises of daily wage earners with limited means to fund their training. The industry should mobilise resources to provide trainers as far as possible.
			Awareness should be built in the local, aspiring workforce to participate in this training	Government (DGET) , NGOs, industry associations should undertake road fairs and other promotional activities in locations around key manufacturing/sourcing hubs to build awareness about such training programmes
			Formulating course content	Course content should be formulated by the Government (DGET) in the lines illustrated

Recommendation and Primary stakeholder responsible	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
				above (see Box 3). Industry and institutes should provide inputs to the Government (DGET) on course content
			Delivery of training – training can be delivered in existing infrastructure (colleges, polytechnics, ITIs) during non-working hours	Responsibility for training delivery shall rest with the Government (DGET, through NCVT). The Government (DGET) can appoint teachers from institutes/private operators/industry representatives who volunteer in this regard. A common standard should be laid down for delivery by the Government (DGET) on the basis of the above suggested curriculum
			Testing and Certification	Testing and Certification can be done by the Government (DGET) through NCVT, by Government authorised third party training providers, industry associations. The delivery, testing and certification have to be performed on the basis of a common

Recommendation and Primary stakeholder responsible	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
				standard laid down by the Government (DGET), in consultation with industry and institutes.

Special target group – women workers:

A large number of persons employed in simple assembly line activities are women[3]. They are preferred by employers because of:

- General attention to detail
- Qualities such as patience
- Ability to perform repetitive activities
- Higher level of precision (evolved from traditional knitting and tailoring skills).

Hence we recommend that this scheme be promoted among women who are unskilled/10th/12th pass/drop-outs so as to aid employment generation among women. Women should be encouraged to take up employment in the electronics industry around key manufacturing hubs. This will enhance their employability and also serve the cause of social equity by creating equal opportunities for employment.

IV. Improving skills for contract manufacturing and assembly operations

This initiative is aimed at improving the skills of people at various levels of manufacturing operations such as operator and supervisor level. India can follow the example of the Penang Skills Development Centre (PSDC) in Malaysia.

[3] This was noted in our visit to the manufacturing units of a leading television manufacturer and a leading mobile handset manufacturer as part of the primary survey. Interactions with other stakeholders confirmed the same.

Case Study: Penang Skills Development Centre

During the early 1980s, Penang and the Northern Region of Malaysia experienced exponential growth, largely due to the value-added products and services created by the manufacturing sector, especially large MNCs. Thousands of youths were employed for their manual dexterity, while educational backgrounds and skills were secondary. However as the local manpower market began to shrink, MNCs were compelled to transform their workforce. Steps were immediately taken to provide a venue to spearhead the transformation and provide training outside the normal education curriculum. Today Penang has been transformed into a producer of some of the most sophisticated microchips and electronic equipment in the world.

PSDC is a joint effort of the country's Government, academia and industry, where the management, expertise and administration are left to the industry. PSDC operates as a non-profit organisation and invites membership from the industry. Participating companies pool their resources together to help plan, design and conduct an extensive range of training programs directly relevant to immediate and forecasted needs. This enables the PSDC to offer the most cost-effective training for the industry and at the same time bridge the gap between skills taught in public institutions and skills required on the job. These trainings have ensured that small and medium industry (SMI) plays an important role in supplying to MNCs and ensuring that these MNCs remain competitive globally. The ability and capacity of SMIs to provide world-class products and services in the supply chain has helped reduce the cost and dependency of MNCs to import these materials.

PSDC conceived and developed the Global Supplier Program (GSP) and the Services Suppliers Program (SSP) in strategic with the MNCs and aimed at upgrading the capability of local companies to be world-class suppliers of services and materials, not only to the MNCs in Malaysia but globally by developing and upgrading the capability of local companies through training.

The GSP involves two initiatives - Training in critical skills and Linkage with MNCs.

1. *Training in critical skills:* This initiative consists of training in critical skills and competencies to adopt and use new technologies. The focus is on quality and productivity. There are three levels of training under this initiative:

- *CoreCom 1:* CoreCom 1 or Core Competencies1 is the first level of training that involves a total of 76 hours or 9.5 training days spread over a period of 4 months. It covers 13 courses. In the spirit of "Shared Learning of Best Practices", the training modules are contributed by MNCs (Agilent Technology, Astec, Eng Teknologies, Robert Bosch, Fairchild Semiconductor, Komag, Intel, Motorola, Penang Seagate). For ease of understanding, case studies and examples shown during training sessions are actual cases within the various MNCs.

  To ensure that there is a linkage between training and supplier development, all trainers come from participating MNCs. The trainers selected are technical personnel with many years of "hands-on" experience. In this way, the MNC trainers can then audit the work done by their suppliers as well as evaluate the effectiveness of the training they conduct.

  Coverage of CoreCom 1
  - Customer Service
  - Cost of Quality
  - Quality Systems Review
  - 5-S Housekeeping
  - Statistical Process Control 1
  - Statistical Process Control 2
  - Calibration + GR+R
  - Design of Experiments
  - 6-Step Problem Solving
  - Basic Management Program
  - Presentation Skills
  - Effective Meetings & Constructive Confrontation
  - Project Management

- *IS 2:* IS 2 or Intermediate Systems is the second level of training and involves a total of 68 hours of training or 8.5 training days spread over a period of 4 months. This is a follow-up to the CoreCom 1 and comprises of the key modules, including an appreciation of QS9000, GR+R,FMEA, Design of Experiments 2, Excel Statistical Software. Participants are expected to go through the CoreCom 1 before embarking on IS 2. Case studies and examples shown are actual industrial practices.
- *AS 3*: AS 3 or Advanced Systems 3 is the third level of training and aims to elevate the SMIs into a predictive mode. This final level requires a large investment and commitment by both vendors and buyers. The proposed courses are: Design Capabilities, CAD/CAM, Design for Assembly, Design for Manufacturability, Simulation - Thermal / Flow / Dynamic, Analytical Capabilities, Surface Analysis, Thermal Analysis, Organic Analysis, Environmental Testing, Modular Courses, Mechanical Engineering, Materials Engineering, Electronics Engineering. The focus on this third level is more on design and simulation. To develop these modules, PSDC works with researchers, designers from the MNCs as well as the academia.

2. *Linkage with MNCs:* This is the linkage program where MNCs adopt local companies and guide them for upgrading leadership skills and technology. The selection criteria for this program are dependent on the "conditions" agreed upon between the MNC and the identified local supplier. It is a long-term commitment of up to 2 years with regular reviews between the MNCs and the SMIs to ensure

deliverables are met. This initiative calls for investment of time and commitment of both the large corporations and SMIs. The success of this linkage would be apparent when suppliers have attained the level of competency and become global players themselves.

Application in the Indian Context

The large OEMs can adopt the small companies and suppliers to upgrade their technical skills through knowledge transfer so that more critical jobs in R&D are handled by them while production and assembly jobs are taken care of by the suppliers.

The objective of the program should be to improve the quality orientation and productivity management abilities of the supervisors at supplier level so that the incidence of faults can be reduced. This will also ensure that skills required for contract manufacturing and assembly operations percolate to Micro, Small and Medium Enterprises. Such enterprises do not have the resources to conduct training programmes in the manner large companies have. Large companies, OEMs, and Industry associations have to take a proactive role in training their suppliers, vendors, small enterprises in contract manufacturing and assembly operations to ensure that the industry as a whole benefits.

The training could be conducted by the leading companies/industry associations in a particular geographic location for their suppliers on non-working days. The existing polytechnics/engineering colleges' infrastructure can be utilised for delivery of training.

The cost of training has to be borne as follows:

- Costs incurred on development of course curriculum to be incurred by the IT Hardware and Electronics Industry (companies, associations, or both)
- Participant fee to be incurred by beneficiary company.

Box 4: Illustrative course content for improving skills for contract manufacturing and assembly operations

The course content for building skills for contract manufacturing/assembly should span across several modules such as

- Quality certifications like Six Sigma
- Productivity measurement
- Process control
- Assembly line scheduling
- Costing and budgeting
- Basic management program, effective meetings, constructive confrontation etc.

These modules can be introduced in the engineering, diploma polytechnics as well.

As outlined in the implementation road map, the primary stakeholders responsible for this initiative are the large OEMs, industry and industry associations.

Implementation Road Map

The implementation road map is presented in the table below with stakeholder action points.

Table 18 : Implementation road map for improving skills for contract manufacturing and assembly

Recommendation and Primary stakeholder responsible	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
Recommendation: ***Improving skills for contract manufacturing and assembly*** Primary stakeholder responsible for implementation: *Large OEMs, industry, industry associations*	Workers at micro, small and medium enterprises engaged in contract manufacturing and assembly	Transfer of knowledge to small enterprises so that they are aware of leading practices and can operate more effectively	Develop location specific, industry specific training programmes for workers in vendor, supplier, and outsourced companies. These training modules will be tailored to the requirements of the OEMs/industry requirements so that the smaller companies/supplier companies can work more	Large OEMs, industry associations such as MAIT, ELCINA, TEMA, CEHA, and others to develop training programmes and depute staff periodically for such programmes

Recommendation and Primary stakeholder responsible	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
			effectively (see illustrative course content in Box 4)	
			Deliver such training at OEM, supplier, or vendor location. If Government (Ministry of HRD) infrastructure (colleges, polytechnics) are used a usage fee can be paid for the same by the beneficiaries.	OEMs, Industry associations to deliver such training on a quarterly/half-yearly basis

V. Creating appropriate infrastructure to train people at operator level

Personnel at the operator level are most likely to be trained in manufacturing related course in ITIs. ITIs in the vicinity of production clusters need to be chosen for the introduction of hardware manufacturing related courses, as the case may be. These courses should provide in detail an overview of production technique, practical exposure to types of products manufactured in the industry, materials and components used, as well as a detailed understanding of processes. For example, the broad processes of assembling should ensure that the following aspects are covered in as much detail as possible, both in theory as well as practical:

- *Multi-skilling:* The industry requires multiple skills amongst workers such as skill sets with both Electronics and Production.

- *Quality Assurance:* Exposure shall be given to quality aspects in the ITI so that workers have an aptitude for ensuring quality production and minimising wastage on assembly/production line.

Besides the above, several soft skills need to be developed at the operator level. These include problem-solving skills, accuracy in work with an eye for detail, handling responsibility, ability to follow instructions, importance of maintenance of tools and machinery used in production, awareness of safe working practices.

As part of the course, in-depth institute-industry interaction is also highly critical, so that the trainees have an exposure to all aspects of working on the shop floor and accordingly hone their functional and soft skills to fit into a production environment.

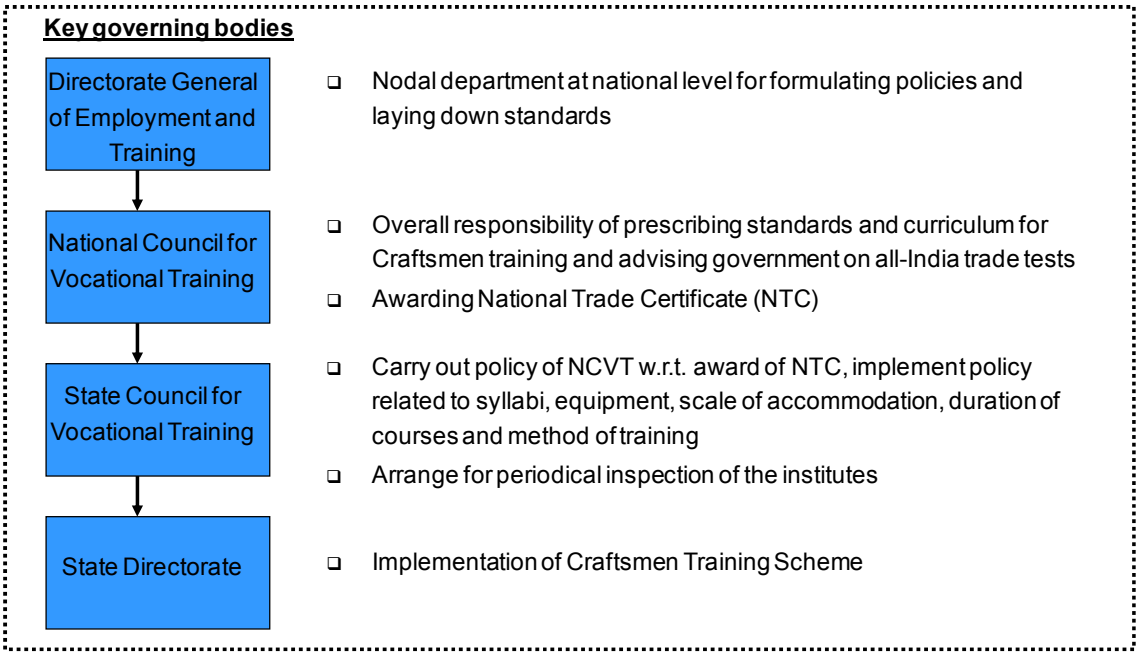
Overview of key bodies associated with vocational training and their roles

The functioning of ITIs is governed by the Directorate General of Employment and Training (DGET) and trades are offered under the Craftsmen Training Scheme (CTS). On successful completion of course, the National Trade Certificate (NTC) is provided by the National Council for Vocational Training. In case of courses having approval of the State Council for Vocational Training, a State Trade Certificate is provided.

Under the CTS, ITIs can introduce new trades by coordinating approval from NCVT, or through the SCVT in case the course is state-specific. Apprentice Training Schemes and Modular Employable Skills schemes are also available.

To make ITI training practical oriented, the local industry would need to co-operate by giving the trainees an opportunity for training on the shop floor as well as allowing industrial visits to the shop floor so that students get to imbibe the industry work culture. With industry support, 1-2 week orientation programmes for ITI faculty should also be undertaken to acquaint them with latest equipment available in the industry. The ITI should be given regular feedback on the industry's annual apprentice requirements. Industry associations can play an active role by leveraging its local contacts in the industry in the vicinity of ITIs to encourage them to assist in building skills.

Figure 19 : Key bodies associated with vocational training and their roles



Our recommendations in this area focus on the following:

- Capacity addition at ITIs to meet higher value addition requirements
- Enhancing the curriculum at ITIs (including new course on e-Waste Management, besides others)
- Creation of basic infrastructure at ITIs through quasi shop floors
- Enhancing the functioning of Placement Cells at ITIs.

Capacity addition at ITIs to meet higher value addition requirements

There are about 1,913 Government ITI and about 3,552 Private ITC in India[4]. The total number of seats in all these ITIs is about 7.5 lakh. This includes both engineering and non-engineering related trades. There are about 1,3010 ITIs and about 1,229 ITCs which offer trades in areas related to IT Hardware and Electronics Manufacturing. Each of these ITIs and ITCs has about 16 to 20 seats per such trades offered operating about two shifts on an average.

As per estimates, there are over 75,000 seats available across various trades in the IT Hardware and Electronics Manufacturing areas. An estimate of the seat availability across various trades in illustrated in the following table.

[4] Information provided under this sub-heading is based on data provided by the Directorate General of Employment and Training, other secondary data, and IMaCS analysis.

Table 19 : Relevant trades and seats available in the IT Hardware and Electronics Manufacturing Industry

List of trades	Govt.		Private	
	No. of ITI	Seats	No. of ITC	Seats
Electronics Mechanic	683	20,490	962	28,860
Mechanic Radio and Television	455	13,650	186	5,580
IT & ESM Maintenance	144	4,320	62	1,860
Wireless Mechanic Operator	13	390	1	30
Mechanic Auto Electrical and Electronics	4	120	6	180
Mechanic General Electronics	4	120	2	60
Mechanic Medical Electronics	3	90	6	180
Mechanic Mechatronics	3	90	-	-
Network Technician	1	30	4	120
Mechanic Computer Hardware	-	-	1	30
Mechanic Consumer Electronics	-	-	5	150
Mechanic Operator Communication System	-	-	4	120
Sub-total	**39,300**		37,170	
Total	**76,470**			

Source: Directorate General of Employment and Training, IMaCS analysis

There has to be higher value addition if the IT Hardware and Electronics Manufacturing Industry needs to substantially increase its growth profile from the current levels. The value addition will be in the manufacture and downstream activities for higher end consumer electronics, mobile handsets, and higher end TVs (such as high end plasma TVs) manufactured in India in the times to come. One of the means towards this is that there is higher skill building at various levels in the industry, especially at the worker/operator level. *This would mean that a substantial portion of personnel currently employed in the industry with 10^{th}/12^{th} standard as their qualification undergo significant skill building through ITIs and other vocational courses*. As per our analysis, we estimate that the requirement of personnel with ITI and vocational courses qualification would increase from the current level of 0.13 million till 2015 to about *0.33 million to 2015*, taking into account the requirement for higher value addition in the manufacturing functions. This would translate to additional capacity being created at ITIs.

While estimating the additional capacity required, we also observe that the effective conversion of seats to those who produce successful out-turns to be in the region of 60% - 70% in ITIs and ITCs[5]. There would be also about 25% to 30% of those passing-out of these institutes joining related functions such as maintenance in other industries as well as seeking self employment. Keeping these factors in mind, our analysis reveals that there would be an additional requirement of *7,500 to 8,000* ITI/ITC/vocational training seats[6] that need to be created.

Focus areas for adding capacity should be:

- Consumer Electronics
- Computer Hardware
- Telecommunication Equipment
- Component Manufacturing.

Trades such as Mechatronics, Network Technician, Operator and Mechanic – Computer Hardware, Operator and Mechanic – Consumer Electronics, Operator – Component Manufacturing, need to be strengthened from the current levels. These trades can be focus areas for additional capacity creation.

The addition of capacity can be planned across the key industrial regions in the proportion indicated in Figure 10 *(Region-wise share of industry).*

The focus course areas/modules are outlined in the following section on *'Enhancing the course curriculum at ITIs'*.

As outlined in the implementation road map, the primary stakeholder responsible for this initiative is the DGET.

Enhancing the curriculum at ITIs

The course curriculum in ITIs needs to be further enhanced to meet the requirements of higher value addition.

Our interaction with the industry and their feedback reveals that the following focus areas is to be added/enhanced in the ITI curriculum:

[5] *'ITIs of India – the efficiency study report'* of the International Labour Organisation, Sub-Regional Office, New Delhi, as measured from capacity utilisation and pass-out rates

Table 20 : Focus areas for enhancing trade curriculum in ITIs

Trade/Topic area	Broad coverage
Consumer Electronics	LCD TVs, Plasma TVs, Assembly line manufacturing for TVs
Computer Hardware	Monitor manufacturing and assembly, including LCD monitors, computer assembly focussed courses, trouble shooting, servicing
Telecommunication	Specific courses on manufacture and servicing of mobile handsets
Component Manufacturing	Soldering automatic and manual, winding, board population, testing and trouble shooting
High Tech Manufacturing	This can be a generalist CoE (the formation of which is outlined in the later sections) level course with focus on operator level for a high tech manufacturing environment for Surface Mounted Technologies, Semiconductors, complex panel displays, with compliance to Quality and Safety.

Source: IMaCS analysis based on discussions with stakeholders

The above trades/topic areas can be introduced with specific focus on '*practical knowledge'*. In order to increase the practical exposure of students, we are suggesting the setting up of *quasi shop floors* at ITIs as outlined in the following section. The enhancement of curriculum, complemented by creation of infrastructure aiding practical learning will increase the skill levels of those passing-out from these institutes.

Additionally, we propose the introduction of courses in Electronics Waste Management as outlined below.

Courses in Electronic Waste Management (e-Waste Management)

Rapid obsolescence of electronic goods, compounded by dumping from developed countries, has acutely increased the problem of electronic Waste (e-Waste) in India[7]. Major contributors of e-Waste include:

- Individuals and small business
- Large corporations, institutions, and Government
- Original Equipment Manufacturers.

e-Waste contains many hazardous toxics such as those outlined in the table below.

[6] The requirement would be higher if the factor of employability is taken into account
[7] Report by Toxics Link, a Delhi based NGO

Table 21 : Usage and Hazards of e-Waste

Chemical/Compound	Usage and Hazard
Lead	This causes damage to the central nervous system, blood systems, kidneys, and reproductive systems in human beings. It is used in glass panels, gaskets in computer monitors, solder in printed circuits and other components.
Cadmium	Toxic cadmium compounds accumulate in the human body, especially in the kidneys. This is used in SMD chip resistors, infra-red detectors, semiconductor chips. Some older cathode ray tubes also contain cadmium.
Mercury	Mercury can cause damage to brain, kidneys, and foetus. When inorganic mercury spreads into water, it is transformed into methylated mercury which bio-accumulates in living organisms, especially fish. It is estimated that nearly 22% of the world mercury consumption is in electronics and electrical equipment. Mercury usage in flat panel displays is bound to increase.
Plastics	Dioxins in released when PVC is burned. Largest usage of plastics (26%) is in electronics.
Brominated Flame Radiants (BFR)	BFRs are used in plastic housings of electronics and motherboard to prevent flammability.
Beryllium	Exposure to beryllium can cause lung cancer, skin diseases, and poor wound healing. This is commonly found in motherboards, and connectors.
Toners	Inhalation causes problems in the respiratory tract.
Phosphor and additives	The phosphor coating on cathode ray tubes contains heavy metals such as cadmium and other rare metals such as zinc, vanadium, and additives. These pose a serious hazard when the monitor is dismantled by hand.

Source: Toxics Link

Given the fact that the growth rates discussed would entail the creation of a large quantity of e-Waste, we feel that the e-Waste Management/Disposal process will become a *more formal/organised activity* in the times to come (currently about 25,000 workers are employed in scrap yards in Delhi alone). This requires the availability of talent so that the industry is prepared for the same. We recommend that modules/courses be created for e-Waste Management in ITIs. (This can be made applicable to Diploma and Engineering also).

The following are the broad content areas for courses/modules in e-Waste Management:

- e-Waste generation and characteristics of e-Waste
- e-Waste collection, storage, and transport
- e-Waste disposal
- e-Waste processing techniques
- Source Reduction, Reuse, Recycle
- Incineration and handling

- Handling hazardous e-Waste
- e-Waste during production process of Electronics and Components – cathode ray tubes, monitors, PCBs, batteries, etc. (refer table above for various chemicals to be included for related e-waste)
- First aid on contact.

As outlined in the implementation road map, the primary stakeholder responsible for this initiative is the DGET.

Basic infrastructure that must be created in the ITIs through 'quasi shop floors'

We recommend that quasi shop floor be set up at ITIs so as to enable students at these institutes to be exposed to current equipment and practices in the industry. These equipment shall be at a basic level and would not include those which are highly capital intensive. Such equipment should be organised in the form of laboratory modules so as to help students get an industry feel/practical orientation of different areas. Exhibit training modules can also be used.

Our interactions with stakeholders reveal that, for a starting point, focus be given to the following areas classified under the heads *'Generic'* and *'Specific'*. We have formulated the equipment list detailed below on understanding from stakeholders that the cost of such as facility would be less than Rs. 10 lakh.

The *'Generic'* modules are applicable to increase exposure to the Electronics Manufacturing industry in general. These can be applicable across sectors in the Production and Service Support functions.

Table 22 : Equipment/training-demonstration modules for quasi shop floor - Generic

Module/Lab to be formed	Type of specific equipment/training-demonstration modules required in the quasi shop floor
Stuffing of electronic boards	• Identification of equipment and components • Basic electronic board population • Sequencing in an assembly line.
Soldering	• Manual soldering equipment • Lead-free soldering • Fume extraction ducts • Goggles • Masks • Hot air blower • Temperature controlled soldering station

Module/Lab to be formed	Type of specific equipment/training-demonstration modules required in the quasi shop floor
	• Training modules on manual rework – desoldering, assembly.
Electro-Static Discharge (ESD) control	Lab to be ESD compliant with the following: • Conduction floor • ESD slippers, covers • ESD wrist bands, caps • ESD combo tester • ESD meters • Cotton apparel, conductive apron • Clean room environment.
Quality and safety module	This module will be a display module on the following lines, with education material, pictures, videos, tool arrangements: • Quality related graphics • Cost of Quality • Educational material/handouts on cost of quality, PDCA • Lay out of hand tools and usage • Power supply and distribution boards • Handling and functionality of equipment displayed • Educational material on ROHS (Restriction Of Hazardous Substances) • Pictures and demos on Emergency drills.
Others	• Modules on programming of Integrated Chips (ICs) for board.

Source: IMaCS analysis based on discussions with stakeholders

The *'Specific'* modules for specific sectors are detailed below.

Table 23 : Equipment/training-demonstration modules for quasi shop floor - Specific

Module/Lab to be formed	Type of specific equipment/training-demonstration modules required in the quasi shop floor
IT Hardware	• 2 to 3 LCD panels and monitors for purposes of demonstration of basic repair • Key sub-assemblies • Power supply units • Controller boards • Training modules on L1 and L2 repair.
Mobiles	• Soldering station • Oscilloscopes • Multimeters

	• SMD displays and repairs • Training modules on L1 and L2 repair.
Consumer Electronics	• Soldering irons and soldering baths • Assembly conveyor • Auto insertion machines • Signal testers and circuit testers
Component Manufacturing	• Inductor winding machines • Resistor winding • Capacitor winding • Dipping machines • Testing machines • Forming machines

Source: IMaCS analysis based on discussions with stakeholders

While it is desirable to have LCD assembly, automatic soldering machines, and plastic injection moulding, the cost of installing the same would be high. *For these specific cases where cost of advanced equipment is prohibitive, we can have video-based demonstration modules complemented by educational visits to the industry.*

The equipment quasi shop floors will also help students work on a certain production order with deadlines so that they understand the commercial aspects of manufacturing. The machinery and equipment required to set up these shop floors would roughly cost Rs. 10 lakh in each ITI, with some donations coming from the industry in the form of depreciated machinery that is replaced by them in their factories. The local industry can also outsource certain job works to the local ITI so that they have an option of internal revenue generation to meet some of their expenses, with active participation of students and supervision by faculty. A certain percentage of revenue generated should be shared with faculty members in order to maintain their interest in such schemes.

As per discussions with stakeholders, the industry would also stand to benefit if the quasi shop floor is made available at the Diploma Polytechnics as well.

As outlined in the implementation road map, the primary stakeholder responsible for this initiative is the DGET.

Enhancing the functioning of Placement Cells at ITIs:

ITIs should have full-fledged placement cells, with at least one dedicated staff member and adequate infrastructure like telephone and computer. These cells would have the sole responsibility to understand the local industry's manpower requirements, communicate the same to the institute and ensure placement of all students. The industry and industry associations should play a proactive role in communicating requirements, which can be made publicly available by hosting on a website (such as the associations web/IT infrastructure). List of pass-outs against specific trades, their marks and contact details should be made available to local industries and maintained till the students secure placement.

As outlined in the implementation road map, the primary stakeholders responsible for this initiative are the institutes.

Implementation Road Map

The implementation road map is presented in the table below with stakeholder action points.

Table 24 : Implementation road map for creating infrastructure to train people at operator level

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
Recommendation: Capacity addition at ITIs to meet higher value addition requirements Primary stakeholder responsible for implementation: *Government – Director General of Employment and Training*	ITIs	Industry and students will benefit as skilled workforce will meet the demand for higher value addition	The output of ITIs should be increased. This should be done through a) adding more seats b) enhancing the utilisation and increasing the pass percentage This is required for meeting increased requirement of technical and vocational skills if industry growth profile is to increase	Government (DGET) should set in place the process for additional seats to be added at ITIs (estimates given above). Government (DGET) should also examine measures to increase utilisation and pass out rates in ITIs.
			Funding additional capacity creation	Primary responsibility of funding the additional capacity expansion rests with the Government (Ministry of Labour).

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
				Industry must participate in this through PPP.
			Capacity addition of existing courses and new courses should be introduced in the following trades - Mechatronics, Network Technician, Operator and Mechanic – Computer Hardware, Operator and Mechanic – Consumer Electronics, Operator – Component Manufacturing, e-Waste Management.	Government (DGET) to decide on the trades and number of seats. This should be done after consulting industry. (Broad seat requirements and trade areas have been outlined)
Recommendation: *Enhancing the course curriculum at ITIs* Primary stakeholder responsible for implementation: *Government – Director General of Employment and Training*	ITIs	Students would benefits due to curriculum being more industry-specific	Identification of specific courses to be added/created to complement capacity addition	Government (DGET) to appoint a nodal agency which will identify additions to existing courses/new courses and trades to be created. The nodal agency would include representatives from the industry, industry associations and institutes.
			Detailed curriculum should be designed	The DGET designated nodal agency should drive the design of curriculum. (New course/trade areas, including the introduction of courses in e-Waste Management have been outlined above in the narration)
			Roll out of curriculum changes	The DGET should roll out the curriculum change. Feedback should be sought from the industry after pass-

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
				outs from these courses join the industry to evaluate the effectiveness of curriculum changes and new course. The agency should make appropriate changes as required on an annual basis.
Recommendation: ***Creation of quasi shop floor at ITIs*** Primary stakeholder responsible for implementation: *Government – Director General of Employment and Training*	Students at ITIs	Students at ITIs are exposed to equipment at shop floors/real-time industrial set up which will make them industry ready	Identification of equipment required as illustrated in the above tables	Government (DGET) and industry (especially the recruiting, local industries at various ITIs) work together to identify the quasi shop floor equipment
			Purchase/funding of quasi shop floor equipment	Government (Ministry of Labour/DGET) takes the lead role in the purchase/funding of equipment. Additional funds are allocated to the ITI for this (as specified earlier). Maintenance is performed by ITIs
			Training students on the quasi shop floor	Training is delivered by Institutes. Local industry should also demonstrate commitment through guest lectures and facilitating industrial visits
			Outsourcing of minor work modules from industry to ITIs which can be performed at the quasi shop floor. This will help students achieve practical, industry-specific exposure	Industry should come forward to outsource minor work modules to ITI which can help ITIs also serve as a mini, outsourced production facility. Such outsourced work can be supervised by industry representatives. If possible, industry can also donate some additional equipment (including

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
				depreciated equipment) in this regard.
Recommendation: ***Placement cells at ITIs*** Primary stakeholder responsible for implementation: *Institutes*	Students at ITIs	Enabling students at ITIs to find employment	Setting up a Placement Cell at the ITI	The institute should set up a dedicated faculty member (Placement Officer) who oversees this activity
			Industry and industry associations must regularly dispatch human resource requirement information, along with skill sets/trade requirements to ITIs	Industry and industry associations (such as MAIT, ELCINA, TEMA, CEHA, and others) can host such information which should have location-specific details in websites, or can mail the same to ITIs
			Placement cell should monitor requirements and communicate with industry to provide prospective candidates from their ITIs List of pass-outs against specific trades, their marks and contact details should be made available to local industries and maintained till the students secure placement.	Institutes should monitor requirements proactively through the Placement Cell. They can also widen industry interaction through the existing IMC framework. This should be done by the institute.

VI. Opening Engineering Finishing Schools for technical graduates

Finishing schools for fresh engineering graduates are required to make them industry-ready. These could be introduced in key institutes for a period of 8-10 weeks in the production clusters of the IT Hardware and Electronics Manufacturing Industry. These need to be introduced in particular for those graduating from the Production and Electronics streams, as a major feedback of the industry is that students from these two streams have inadequate knowledge about their own courses.

Reference Model – NASSCOM IT/Engineering Finishing School: These Finishing Schools could be along the lines of those opened by NASSCOM in partnership with the Ministry of Human Resource Development under the 'Finishing Schools for Engineering Students' programme. These schools are expected to enable young technical graduates to become industry-ready. The 'Finishing School' for engineering graduates who are still seeking employment was launched in a pilot mode in May 2007 for a period of eight weeks in eight institutions, including IIT Roorkee and seven NITs—Calicut, Durgapur, Kurukshetra, Jaipur, Suratkal, Trichy and Warangal.

The 'Finishing School' covers the curriculum provided on technical and soft skills development. It gives students the opportunity to reinforce some basic engineering skills and in addition, acquire industry-specific knowledge and skills, soft skills, and management and employment skills. Training is delivered by trained faculty and practicing IT and ITES industry consultants. The curriculum and syllabi for these Finishing Schools is finalised by the coordinators of these schools and the representatives of companies that intend to hire these graduates.

As part of the program, the students also receive periodical feedback on their performance and undertake a final exam that highlights their ability in the area of rational, analytical thinking processes identified in a problem solving environment. The students have the opportunity to take the NAC-Tech (NASSCOM Assessment of Competence–Tech), an employment benchmarking test and participate in a Job Fair.

Setting up Finishing schools for the IT Hardware and Electronics Manufacturing Industry

We propose that the concept of Finishing Schools should be implemented for the IT Hardware and Electronics Manufacturing Industry. Training modules, with a total duration of 8-10 weeks, could be introduced as separate courses or as modules of existing courses. These courses/modules can be introduced even over and above the existing curriculum, wherein students of the engineering streams get trained to make them industry-ready.

The courses content would be focussed in the following areas:

- Production and Assembly
- Design and Development
- Other areas deemed of interest to the industry from time to time.

The broad course structure for these content areas can be derived from our references to these topic-areas in other recommendations. The testing and certification for these courses can be undertaken by the industry along the lines of NAC-Tech.

As this skill building measure is to be owned by industry, industry associations and companies have to play a lead role in rolling out the Finishing Schools for the IT Hardware and Electronics Manufacturing Industry.

An implementation road map is required for this roll out, which is available in the following section.

Implementation Road Map

The implementation road map is presented in the table below with stakeholder action points.

Table 25 : Implementation road map for opening finishing schools for technical graduates

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
Recommendation: *Opening finishing school for engineering graduates* Primary stakeholder responsible for implementation: *Industry/industry associations such as MAIT, ELCINA, TEMA, CEHA, and others*	Engineers and later extended to Diploma	Equipping engineering students with courses to make them industry ready	Appointing a nodal agency to oversee the training formulation and delivery	Industry/industry associations (such as MAIT, ELCINA, TEMA, CEHA, and others)
			Deciding the course contents of industry specific training requirement	Industry associations (as these courses are outside of the normal education curriculum/delivery and are anchored by industry)
			Selecting training institutions and training personnel (from industry/consultants/operators)	Industry working along with institutes/consultants/private operators
			Delivery of training at own locations/colleges/ITIs	Industry and Government (Ministry of Human Resource Development, Department of Technical Education) work together and industry secures Government permission for use of infrastructure (such as college classrooms) for training delivery, wherever required, on a fee for use basis
			Testing and Certification	Testing to be performed by industry approved agencies on common guidelines.

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
				Government (Ministry of Human Resource Development/Department of Technical Education) will have an advisory role.

VII. Capacity Addition and Curriculum Upgradation in Technical Education

The presence of adequate capacity is critical in ensuring appropriate availability of skilled human resources in the IT Hardware and Electronics Manufacturing Industry. This has to be backed by initiatives to ensure currency of curriculum. Our analysis[8] on the above dimensions focusses on the following educational supply streams:

- Research – Doctoral and Post Graduation
- Engineering
- Diploma Polytechnics.

Capacity addition in Research – Doctoral and Post Graduation

India has over 6,000 science Ph.D (Doctorates). This has to be viewed in the context of USA, which has over 27,000 Ph.Ds, and China which has over 10,000 Ph.Ds in engineering and science. Moreover, China is also close to overtaking USA in the total number of Ph.Ds in all disciplines put together, including non-science related. This reveals that India still has a long way to go when compared to its aspirations in the areas of Research.

Our analysis reveals that there are nearly 1,350 seats[9] in the areas of Post Graduate studies (ME and MTech) pertaining to the IT Hardware and Electronics Manufacturing Industry. Courses offered pertain to Electronics and Power Engineering, Electronics and Communication Engineering, Electronics Engineering, Industrial Electronics, Electrical and Electronics Engineering, and Electronics and Instrumentation Engineering. About 550 Ph.Ds are produced in the areas related to Electronics Engineering in India, as per our analysis and assumptions.

[8] Analysis in this section is based on information gathered from multiple secondary sources and related assumptions
[9] Select Educational Statistics – Department of Higher Education, Ministry of Human Resource Development

Thus, the total number of Doctoral and Post Graduate students outturning in India is estimated to be over 1,900 in Electronics and related areas. Our analysis reveals that over 62,000 Ph.D and Research Scholars are required in the IT Hardware and Electronics Manufacturing Industry till 2015. This has to be met primarily by the Doctoral and Post Graduate Educational streams and translates to an incremental annual requirement of about 7,800 seats in these streams as against the current capacity of 1,900. As is obvious, the current capacity is not sufficient to meet required demand. This could impact the industry adversely as the IT Hardware and Electronics Manufacturing Industry is relatively 'research-heavy'/'research-centric' as compared to other industries. We thus estimate that additional infrastructure for outturning about 6,500 Doctorates/Ph.Ds and Post Graduates need to be created in India. This would imply creating adequate infrastructure for about 1,300 Doctoral seats and about 5,200 Post Graduate (ME/MTech) seats.

Focus areas/specialisation for such capacity creation should include the following, in addition to the existing areas:

- VLSI and Embedded Systems
- Semi conductors
- Nanotechnology
- Microelectronics.

Capacity addition and curriculum updation in Electronics and related areas of Engineering

Capacity addition in Electronics and related areas of Engineering

The following table presents a snapshot of available seat capacity in Engineering in all streams as well as those courses related to Electronics Engineering in a cross section of large states in India.

Table 26 : Engineering seats in a cross section of states in India

State	Total no. of engineering seats	No. of seats in electronics related courses
Tamil Nadu	93,469	28,842
Karnataka	55,000	21,450
AP	98,793	41,966
Maharashtra	71,691	20,580
Rajastan	20,755	7,264
Punjab	14,180	3,692

Source: Directorate of Technical Education of various states, IMaCS analysis

These states account for over 50% of the seat capacity in Electronics related courses (Electronics and Communication Engineering, Electrical and Electronics Engineering, Electronics and Instrumentation Engineering, Electronics Engineering, etc.).

We estimate that the total capacity of Electronics and related Engineering courses in India to be over 2,40,000. The IT Hardware and Electronics Manufacturing Industry incrementally requires around 3,90,000 Electronics Engineers[10] till 2015, translating to a requirement of about 50,000 Electronics Engineers annually[11]. While the current capacity appears to be more than required demand, allowances need to be made for factors such as utilisation of seat capacity, pass percentages, as well as a percentage of students proceeding for higher studies. Furthermore, this talent pool is also a ready-recruitment pool for the IT Industry to which about 60% to 70% of the students head for[12]. Taking into account all these factors, we estimate that additional capacity to the extent of 17,000 to 20,000 engineering seats need to be created in Electronics and related courses. This has to be further supplemented by initiatives to attract talent into this industry.

Curriculum updation in Engineering in Electronics related areas

Increase in seat capacity has to be complemented by curriculum updation to ensure that the students graduating from these streams are of adequate quality, as evidenced by inputs received during our interaction with various stakeholders. We propose that curriculum updation be targeted in the following areas:

- Design and Development
- High Tech Manufacturing.

We have outlined the illustrative and broad course content areas for the above two topic areas in *Box 5* and *Box 6* of this report. In addition, e-Waste Management should be also included in the curriculum.

Capacity addition and curriculum updation in Diploma Polytechnics in Electronics and related areas

Capacity addition in Diploma Polytechnics

The following table presents a snapshot of available seat capacity in Diploma Polytechnics in all streams as well as those courses related to Electronics in a cross section of large states in India.

[10] Engineers in Electronics related streams - Electronics and Communication Engineering, Electrical and Electronics Engineering, Electronics and Instrumentation Engineering, Electronics Engineering, etc.
[11] Based on our analysis in the previous sections on incremental human resource requirements
[12] National Technical Manpower Information System (NTMIS) on sample states

Table 27 : Diploma seats in a cross section of states in India

State	Total no. of diploma seats	No. of seats in electronics related courses
Tamil Nadu	71,662	17,916
Karnataka	69,918	10,807
AP	21,670	7,620
Maharashtra	64,405	9,955
Rajasthan	8,580	1,940
Punjab	4,225	1,770

Source: Directorate of Technical Education of various states, IMaCS analysis

These states account for about 50% of the seat capacity in Electronics related courses in Diploma Polytechnics (Electronics and Communication Engineering, Electrical and Electronics Engineering, Electronics and Instrumentation Engineering, Electronics Engineering, etc.).

We estimate that the total capacity of Diploma Polytechnic courses in Electronics and related areas in India to be over 1.1 lakh. The IT Hardware and Electronics Manufacturing Industry incrementally requires around 2.75 lakh diploma engineers till 2015, translating to a requirement of about 34,000 Diploma holders in Electronics and related areas annually. While the current capacity appears to be more than required demand, allowances need to be made for factors such as utilisation of seat capacity, and pass percentages. Furthermore, about 35% to 40% of the diploma holders proceed for further studies (engineering) in addition to taking up jobs in other industries. Taking into account all these factors, we estimate that additional capacity to the extent of 11,500 to 13,500 diploma polytechnic seats need to be created in Electronics and related courses. This has to be further supplemented by initiatives to attract talent into this industry.

Curriculum updation in Diploma Polytechnics in Electronics related areas

Increase in seat capacity has to be complemented by curriculum updation to ensure that the students graduating from these streams are of adequate quality, as evidenced by inputs received during our interaction with various stakeholders. We propose that curriculum updation be targeted in the following areas:

- Manufacturing, supervisory aspects, and equipment related areas of High Tech Manufacturing (areas outlined in *Box 6* of the report)
- e-Waste Management.

In addition, *'quasi shop floors'*, as detailed in the previous sections, can be extended to Diploma Polytechnics as well.

The primary stakeholder responsible for the capacity addition and curriculum updation in technical education would be the Department of Higher and Technical Education of the Ministry of Human Resource Development, as outlined in the implementation road map.

Implementation Road Map

The implementation road map is presented in the table below with stakeholder action points.

Table 28 : Implementation road map for capacity addition and curriculum updation in Technical Education

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
Recommendation: ***Capacity addition in Research – Doctoral and Post Graduate areas*** Primary stakeholder responsible for implementation: *Government – Department of Higher and Technical Education/Ministry of Human Resource Development*	Doctoral and Post Graduate colleges	Industry and students will benefit as skilled workforce will meet the demand for higher value	The output of research streams – Doctoral (Ph.D) and Post Graduate streams (ME/MTech) needs to be increased. This is required to meet the high skill requirement of the IT Hardware and Electronics Manufacturing Industry	Government (Department of Higher and Technical Education/Ministry of Human Resource Development) should set in place the process for additional seats to be added at Ph.D and ME/MTech levels (estimates given above).
			Funding additional capacity creation	Primary responsibility of funding the additional capacity expansion rests with the Government (Ministry of Human Resource Development). Industry must participate in this through PPP.

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
			Capacity addition of existing courses and new courses should be introduced in the following areas – VLSI, Embedded Systems, Microelectronics, Nanotechnology, Semi conductors.	Government (Ministry of Human Resource Development) to decide on the specific seat wise increase and curriculum. This should be done after consulting industry.
Recommendation: ***Capacity addition and curriculum updation in Electronics and related areas of Engineering and Diploma Polytechnic streams*** Primary stakeholder responsible for implementation: *Government – Department of Higher and Technical Education/Ministry of Human Resource Development*	Engineering colleges and Diploma polytechnics	Industry and students will benefit as skilled workforce will meet the demand for higher value	The output of electronics engineering and related areas need to be increased in engineering and diploma polytechnic streams. This is required to meet the high skill requirement of the IT Hardware and Electronics Manufacturing Industry	Government (Department of Higher and Technical Education/Ministry of Human Resource Development) should set in place the process for additional seats to be added at Electronics Engineering levels and Diploma Polytechnic levels (estimates given above).
			Funding additional capacity creation	This would be both Government funded (through Ministry of Human Resource Development), as well as private funded, as

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
				evidenced by the host of private/unaided engineering colleges and diploma polytechnics that have come up. However, the Government would have overall responsibility for educational standards and curriculum.
			Curriculum updation	Government (Department of Higher and Technical Education) to take a lead role in developing detailed curriculum (in areas outlined in the report). Government (Department of Higher and Technical Education) to obtain inputs from industry and institutes in this regard. The implementation mechanism that has been detailed in the later section on High Tech Manufacturing can be followed in this case too.

VIII. National/Regional Centres of Excellence for Design and Development skills

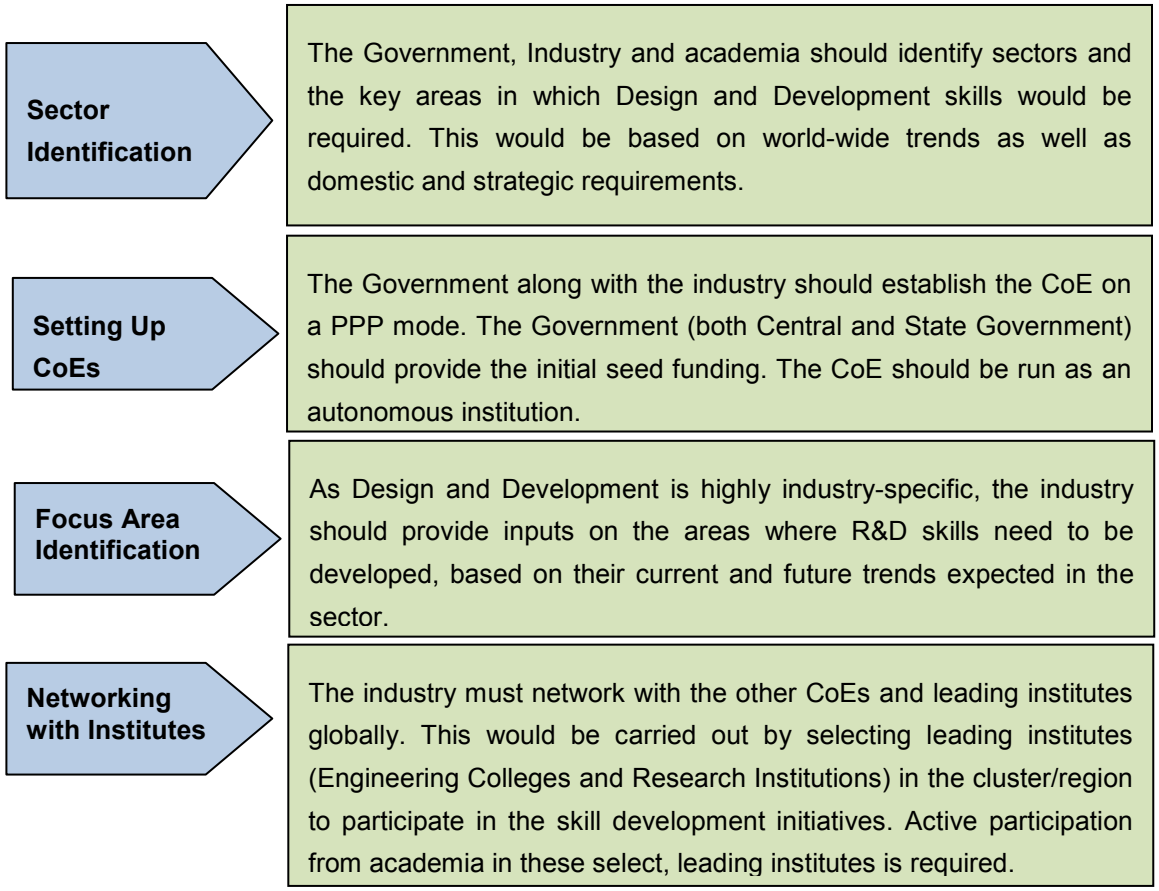
Objective: Design and Development function, though employing a smaller proportion of human resource, is the driver of competitiveness in the IT Hardware and Electronics Manufacturing Industry.

Proposed solution

National/Regional Centres of Excellence (CoE) need to be developed as a measure to build skills in Design and Development. The regions proposed for the rolling out of the initiative to develop Design and Development skills include NCR, Chennai, Bengaluru and Mumbai.

The proposed mechanism to set up these CoEs to facilitate skill development in the Design and Development function is illustrated as follows:

Figure 20: Skill building in Design and Development



Target Groups: We propose that there be two sets of target groups – one being the student community and the other being junior to mid-level executives in Design and Development function.

- Group 1 – BE/B Tech/ME/M Tech/Ph D students in Electronics, and Computer Science and Engineering who intend to pursue a career in Design and Development
- Group 2 – Junior and Mid Level executives/in-house talent identified by companies to perform Design and Development functions.

It is felt that a cluster level network of companies, institutes, professionals, and students focussed on Design and Development would help facilitate skill building in this niche area.

Box 5: Illustrative areas for Design and Development courses

The proposed content areas for Design and Development are as follows:

- Architecture Definition
- Design - Embedded and VLSI, RTOS Design
- Integration
- Validation (Pre and Post Silicon)
- Test case design
- RTL design
- Simulation through computer aided tools (PSpice, MATLAB)
- Implementation of Design on Printed Circuit Boards (PCBs)

The content areas are mainly focussed on the Design and Development of Components, where the R&D requirements are the highest. A similar model can be extended to other fields, such as Telecom, Consumer Electronics. as well.

These CoEs will focus exclusively on the development of Design and Development skills. As outlined in the implementation road map, the primary stakeholder responsible for this initiative will be the Department of Information Technology.

Implementation Road Map

The implementation road map is presented in the table below with stakeholder action points.

Table 29 : Implementation road map for setting up Centres of Excellence in Design and Development Skills

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
Recommendation: *Setting up of Centres of Excellence for design and development Skills* Primary	Engineering students in final year and working professionals employed in these areas	Skills in Design and Development which are relevant to the industry are percolated into the students	Setting up the Centres of Excellence through the PPP route	The Government (Department of IT - DoIT) should take the lead role in setting up the CoE. The CoE should be an autonomous body with representatives from the Government (DoIT) and

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
stakeholder responsible for implementation: *Government – Department of IT*		and working professionals thereby increasing the supply of human resources in this niche area		industry. Funding should be through the PPP route with active industry involvement.
			Design of training programmes	The autonomous body for the CoE should be responsible for the design of training programmes. The broad course contents are outlined in Design and Development above which should be detailed (see Box 5). Industry should actively participate in formulating the course content and training modules. Ministry of Human Resource Development/Department of Higher and Technical Education should support the autonomous body in the design of training programmes.
			Delivery of training	Training should be delivered by persons appointed/invited by the CoE. Industry should actively provide trainers and inputs.
			Testing and Certification	The testing and certification of certificate level courses in Design and Development should be undertaken by the autonomous body responsible for the CoE.

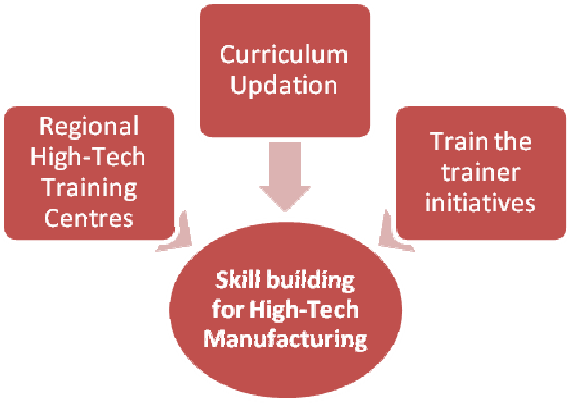
IX. Imparting specialised training for emerging high technology manufacturing

Objective: It is expected that the level of sophistication of skills required in the IT and Electronics Hardware sector will increase when there is a corresponding increase in the high technology (high-tech) manufacturing activity in the country. Investments in sectors like photo voltaic cells, LCD TVs etc. necessitate the focus on high technology manufacturing.

Proposed Solution

We propose a three-pronged approach towards skill development in High-Tech Manufacturing for the IT Hardware and Electronics Manufacturing Industry.

Figure 21 : Skill development in High-Tech Manufacturing



Regional High-Tech Training Centres: Regional High-Tech Training Centres need to be established and well-equipped with state-of-art laboratory facilities as well as appropriate facilities for the delivery of training. Four such state-of-the-art centres should be set up at the major clusters, namely, NCR, Chennai, Mumbai, and Hyderabad.

The equipment at these Centres, the courses conducted, should be aligned to the emerging areas of High-Tech Manufacturing – namely chip mounted technologies, manufacturing LCDs and electronics with sophisticated LCDs, plasma displays, high degree of automation and miniaturisation and nanotechnology.

The Centres should be developed jointly by the Government and the Industry through the PPP route. It should act as a *shared-service* centre for the following purposes:

- Conduct training for the existing workforce to expose them to High-Tech Manufacturing. It can serve as a shared-service training centre for conducting training to industry employees (with the fee being charged on a 'usage' basis).
- Serve as a training ground for students in the area of High-Tech Manufacturing, build awareness and practical insight in the student community
- Can also serve as a shared-service for small units wanting to use these facilities towards accessing some of the High-Tech equipment, which will also build skills in the workforce in the small companies. They can also use the infrastructure for experimentation and research before deciding to purchase certain capital equipment.
- It can also have advisory capabilities helping companies making the transitioning to High-Tech Manufacturing.

Box 6: Illustrative course content in high-tech manufacturing

The areas where inclusion/updation is required in the area of high-tech manufacturing are:

- Chip Mounted Technologies
- Complex LCD Technologies
- Semi conductor Technologies
- Plasma displays
- Nanotechnology.

The curriculum should be developed in consultation with the Industry – should be updated periodically once in two years to incorporate new technologies/ new products.

Certain generic skills need to be built for High-Tech manufacturing. Skill building in the following areas is required for Engineers in colleges (with industry inputs, in the 3rd and 4th years of the course), with specific focus in the Operations and Maintenance of High-Tech processes:

- Exposure to high speed automatic lines
- PLC
- Robots and neumatics
- Instrumentation
- Quality techniques such as SPC and SQC
- Process functions in automated line
- Exposure to compliance to Six Sigma.

Curriculum updation in Engineering colleges: The need for such courses (both specific and generic) is further highlighted by the fact that while Electronics Engineers lack skills and exposure to Production processes, Mechanical Engineers lack sufficient exposure to Electronics, but the industry/shop floor expects multi-skilling in both these areas. *See Box 6 for illustrative course content which can be introduced.*

The target groups for the updation of curriculum are:

- BE/BTech/ME/MTech graduate/post-graduate courses in Electronics, Communication, and Electrical Engineering
- Diploma graduates in Electronics and Electrical Engineering.

Train the Trainer initiatives: One of the key issues facing the educational institutes is the teacher's lack of exposure to latest manufacturing techniques. A large proportion of teachers have very little industry experience. In order to overcome this it is recommended that large companies which have High-Tech Manufacturing equipment and production facilities should train teachers from select institutes. This can be on the basis of a Memorandum of Understanding (MoU) where the Institute and Industry get benefitted as follows.

- Institutes – As the teachers are exposed to current High-Tech Manufacturing, it is expected that they percolate the knowledge obtained to the students on:
  - What these technologies are?
  - What is the core function?
  - What are the basics of operations?
- Industry – Institutes where teachers have been exposed to such training will imply increased awareness among the institute's students. The industry can have training tie-ups with such institutes. These institutes will also serve as a fertile recruiting ground for companies and incentivise them to engage in the same.

Implementation Road Map

The implementation road map is presented in the table below with stakeholder action points.

Table 30 : Implementation road map for High Tech Training Centres

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
Recommendation: *Regional High Tech Training Centres*	Existing workforce, Engineering students, small and	Existing workforce will be trained in high technology	Nodal agency to conceptualise and establish the centres	The Government (Department of IT – DoIT) will appoint a nodal agency which will be ultimately responsible for these

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
Primary stakeholder responsible for implementation: *Government – Department of IT*	medium enterprises	areas, engineering students completing graduation can be trained in such areas, shared service centre for small and medium enterprises		Centres. The agency will comprise of Government (DoIT) and Industry representatives/associations who evince interest in this initiative as the Centres will be established through the PPP route
			Identification of equipment	An illustrative composition of technologies where equipment is required with focus on High Tech Manufacturing has been outlined in this section. The nodal agency will work towards the identification of such equipment as relevant to the interest of overall development of High-Tech Manufacturing.
			Funding of Purchase	Funding the Centres will be through the PPP route with the Government (Ministry of Communications and IT) and Industry actively partnering in the initiative. The nodal agency will purchase the equipment through such funds raised in the PPP mode.
			Use of High Tech Manufacturing Centres	Institutes will use the infrastructure at these Centres to train final year students in engineering to enable exposure to High-Tech Manufacturing machinery and processes. Industry/industry

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
				associations will use the Centres to train existing workforce in High-Tech Manufacturing. Small and Medium Enterprises can use the infrastructure for specific purposes, such as experimentation and research, on a pay for use basis.
Recommendation: *Curriculum updation in engineering* Primary stakeholder responsible for implementation: *Government – Department of Higher and Technical Education*	Engineering students and Diploma Polytechnics students	Engineering students are prepared in areas that are of industry-specific and relevant	Detailed course curriculum is developed based on the areas outlined above	Government (Department of Higher and Technical Education) to take a lead role in developing detailed curriculum (further building upon that outlined in Box 6). Government (Department of Higher and Technical Education) to obtain inputs from industry and institutes in this regard
			Such courses are offered at Engineering colleges and Diploma polytechnics	Institutes offer such courses as part of their curriculum either as a compulsory subject or as an elective
			Guest lectures and training aids to supplement courses	Industry should participate in guest lectures in these courses specific to High-Tech Manufacturing and also provide training aids so as to share their expertise in these areas.
Recommendation: *Train the trainer initiatives*	Teachers in Engineering colleges,	Teachers are exposed to current	Identify institutes and teachers for involvement in the	Industry/industry associations should take a lead role and identify

Recommendation	Target group	Benefit	Implementation action point	Stakeholder responsible for the action point
Primary stakeholder responsible for implementation: *Industry/industry associations*	Diploma polytechnics, ITIs	practices in the IT Hardware and Electronics Manufacturing Industry	train the trainee programmes	institutes which can be a part of this programme. An MoU can be signed with the institutes and with their help, teachers can be identified
			Deliver training programmes and/or permit teachers to work in certain specific projects modules in the Industry in the High Tech areas	Industry/Industry associations must periodically train faculty members of institutes, atleast on a half-yearly basis. They should also enable teachers to have exposure to High Tech Manufacturing areas by means of projects at their premises. Government (Ministry of Human Resource Development/Department of Higher and Technical Education) should permit such interaction and play an advisory role in this initiative.

High level risks: The key challenges in the implementation of various recommendations are as follows:

- Speed of implementation
- Availability of funds.

Mitigating mechanisms: It is suggested that the speed of implementation be effectively monitored against various action points. The various recommendations should be implemented over a one year timeframe and should continue thereafter for the next five year period, with a pilot implementation at the end of 6 to 8 months to check effectiveness. The primary stakeholder for each recommendation would be responsible for ensuring its implementation and conducting a *review of the outcomes* of the initiative based on parameters such as number of jobs created, survey of stakeholder feedback. The lack of funds should be met by using the PPP route rather than relying wholly on Government funding. The industry should participate effectively in these initiatives.

Aligning initiatives to manufacturing clusters

The above initiatives can be specifically targeted at key clusters for the IT Hardware and Electronics Manufacturing Industry. The clusters are spread across different geographical regions of the country and specialise in specific sectors of the Industry. For example, while the Bengaluru-Hosur cluster focusses on IT and Telecom related areas, Consumer Electronics finds a dominant place in the NCR cluster.

The following table details how the initiatives in the above recommendations can be aligned to specific clusters. This table serves to indicate the thrust of the initiative and the importance of the relevant portion of the initiative/focus area for the specific cluster, but does not imply that the initiative is to be restricted to the cluster alone.

Industry segment	Clusters	Initiatives	Focus areas in the initiatives aligned to the cluster
Telecom Equipments, IT and design of high end components	Chennai-Pondicherry, Bengaluru-Hosur, Hyderabad	Courses for after-sales service support	Servicing of IT Hardware Servicing of Telecom Equipment and handsets
		Courses for sales	Sales of computer and IT Hardware
		Opening engineering finishing schools	Engineering finishing schools will help in building industry-specific skills. For these clusters, the focus will be *Design and Development*

Industry segment	Clusters	Initiatives	Focus areas in the initiatives aligned to the cluster
		Capacity addition and curriculum updation in research and engineering	Capacity addition and curriculum updation in Research and Engineering to be focussed on: • VLSI and Embedded Systems • Semi conductors • Nanotechnology • Design and Development • High Tech Manufacturing.
		Centres of Excellence in Design and Development	Building high end skills in Design and Development focussing on: • Architecture Definition • Design - Embedded and VLSI, RTOS Design • Integration • Validation (Pre and Post Silicon) • Test case design • RTL design.
Consumer Electronics, Industrial Electronics, and Component Manufacturing	*Western region:* Mumbai-Navi Mumbai, Pune-Aurangabad-Nashik *Northern*	Courses for after-sales service support	Servicing of Consumer Electronics – LCD TVs, DTH, servicing of CD/VCD/DVD players, servicing of Air Conditioners, Heaters, Coolers.

Industry segment	Clusters	Initiatives	Focus areas in the initiatives aligned to the cluster
	region: Uttarkhand, Himachal Pradesh, NCR and nearby areas		
		Courses for sales	Sales of Consumer Electronics, B2B sales, etc.
		Assembly and related skills, as well as shop floor ethics at grass root level	Applicable to Consumer Electronics, Industrial Electronics, and other manufacturing related activities
		Skills for contract manufacturing	Applicable to segments involving OEM-supplier/vendor manufacturing outsourcing relationships
		Creating appropriate infrastructure to train people at operator level	Quasi shop floor and related initiatives can be focussed on a priority basis in these manufacturing clusters as the students for these clusters at vocational level will be predominantly from the nearby regions
		Opening engineering finishing schools	Engineering finishing schools will help in building industry-specific skills. For this cluster , the focus will be *Production and Assembly*
		Setting up High-Tech Manufacturing Centres	These Centres can be set up where high end consumer electronics is being manufactured, such as the

Industry segment	Clusters	Initiatives	Focus areas in the initiatives aligned to the cluster
			clusters mentioned. The equipment at these Centres, the courses conducted, should be aligned to the emerging areas of High-Tech Manufacturing – namely chip mounted technologies, manufacturing LCDs and electronics with sophisticated LCDs, plasma displays, high degree of automation and miniaturisation and nanotechnology.

Note: The details of the above initiatives/recommendations, illustrative course content, and implementation mechanisms have been clearly outlined in the previous sections.

Annexure 1: Skill Development in certain other countries

This annexure has been presented to illustrate the flavour of relevant skill development activities in other countries, specifically in the area of Information and Communication Technology. Our recommendations in the earlier sections present areas of improvements customised and suitable to the Indian context and to the Indian IT Hardware and Electronics Manufacturing Industry.

Skill Development in Malaysia

Example of skill development in Penang

During the early 1980s, Penang and the Northern Region of Malaysia experienced exponential growth, largely due to the value-added products and services created by the manufacturing sector, especially large MNCs. Thousands of youths were employed for their manual dexterity, while educational backgrounds and skills were secondary. However as the local manpower market began to shrink, MNCs were compelled to transform their workforce. Steps were immediately taken to provide a venue to spearhead the transformation and provide training outside the normal education curriculum. Today Penang has been transformed into a producer of some of the most sophisticated microchips and electronic equipment in the world.

PSDC is a joint effort of the country's Government, academia and industry, where the management, expertise and administration are left to the industry. PSDC operates as a non-profit organisation and invites membership from the industry. Participating companies pool their resources together to help plan, design and conduct an extensive range of training programs directly relevant to immediate and forecasted needs. This enables the PSDC to offer the most cost-effective training for the industry and at the same time bridge the gap between skills taught in public institutions and skills required on the job. These trainings have ensured that small and medium industry (SMI) plays an important role in supplying to MNCs and ensuring that these MNCs remain competitive globally. The ability and capacity of SMIs to provide world-class products and services in the supply chain has helped reduce the cost and dependency of MNCs to import these materials.

PSDC conceived and developed the Global Supplier Program (GSP) and the Services Suppliers Program (SSP) in strategic with the MNCs and aimed at upgrading the capability of local companies to be world-

class suppliers of services and materials, not only to the MNCs in Malaysia but globally by developing and upgrading the capability of local companies through training.

The GSP involves two initiatives - Training in critical skills and Linkage with MNCs.

2. *Training in critical skills:* This initiative consists of training in critical skills and competencies to adopt and use new technologies. The focus is on quality and productivity. There are three levels of training under this initiative:

- *CoreCom 1:* CoreCom 1 or Core Competencies1 is the first level of training that involves a total of 76 hours or 9.5 training days spread over a period of 4 months. It covers 13 courses. In the spirit of "Shared Learning of Best Practices", the training modules are contributed by MNCs (Agilent Technology, Astec, Eng Teknologies, Robert Bosch, Fairchild Semiconductor, Komag, Intel, Motorola, Penang Seagate). For ease of understanding, case studies and examples shown during training sessions are actual cases within the various MNCs.

  To ensure that there is a linkage between training and supplier development, all trainers come from participating MNCs. The trainers selected are technical personnel with many years of "hands-on" experience. In this way, the MNC trainers can then audit the work done by their suppliers as well as evaluate the effectiveness of the training they conduct.

Box 7: Coverage of CoreCom 1

- Customer Service
- Cost of Quality
- Quality Systems Review
- 5-S Housekeeping
- Statistical Process Control 1
- Statistical Process Control 2
- Calibration + GR+R
- Design of Experiments
- 6-Step Problem Solving
- Basic Management Program
- Presentation Skills
- Effective Meetings & Constructive Confrontation
- Project Management

- *IS 2:* IS 2 or Intermediate Systems is the second level of training and involves a total of 68 hours of training or 8.5 training days spread over a period of 4 months. This is a follow-up to the CoreCom 1 and comprises of the key modules, including an appreciation of QS9000, GR+R,FMEA, Design of Experiments 2, Excel Statistical Software. Participants are expected to go through the CoreCom 1 before embarking on IS 2. Case studies and examples shown are actual industrial practices.
- *AS 3*: AS 3 or Advanced Systems 3 is the third level of training and aims to elevate the SMIs into a predictive mode. This final level requires a large investment and commitment by both vendors and buyers. The proposed courses are: Design Capabilities, CAD/CAM, Design for Assembly, Design for Manufacturability, Simulation - Thermal / Flow / Dynamic, Analytical Capabilities, Surface

Analysis, Thermal Analysis, Organic Analysis, Environmental Testing, Modular Courses, Mechanical Engineering, Materials Engineering, Electronics Engineering. The focus on this third level is more on design and simulation. To develop these modules, PSDC works with researchers, designers from the MNCs as well as the academia.

4. *Linkage with MNCs:* This is the linkage program where MNCs adopt local companies and guide them for upgrading leadership skills and technology. The selection criteria for this program are dependent on the "conditions" agreed upon between the MNC and the identified local supplier. It is a long-term commitment of up to 2 years with regular reviews between the MNCs and the SMIs to ensure deliverables are met. This initiative calls for investment of time and commitment of both the large corporations and SMIs. The success of this linkage would be apparent when suppliers have attained the level of competency and become global players themselves.

Skill Development in Singapore

Institute of Technical Education

The Government of Singapore through the Institute of Technical Education (ITE) system has integrated its skill development program with the education system of Singapore. The Mission of ITE is ―To create opportunities for school leavers and adult learners to acquire skills, knowledge and values for lifelong learning in the global economy.

The ITE System has three colleges - The ITE East, ITE West and ITE Central. The complete vocational training for Singapore is done in these colleges. They cater to about 25% of the student population. ITE system is accredited in the worldwide and finds wide acceptance in most developed countries. The Government of Singapore realizes the importance of skilling the bottom 30 % of the population and invests nearly 1.5 % of its GDP in this area.

It also understands the importance The ITE system creates opportunities for school leavers and adult learners to acquire skills, knowledge and values for lifelong learning in a global economy. ITE also functions as a post –secondary institution. One of the most important models that ITE uses is the win – win partnerships of Joint certification with the Industry Leaders. ITE has signed about 61 Memorandum of Understanding (MoUs) with leading player from a wide range of industries. Some of the important ones are:-

- Sun Microsystems
- Microsoft
- METI

- Center for Healthcare Simulation Training.
- ABB
- Automation Technology solutions.
- Omron Application Solution Center.
- IBM
- Retail Industry leaders
- Leading Beauty Therapy leaders
- Building security control and air-conditioning systems
- Smart Homes.

In addition, the ITE has a specialized ITE Education Services arm. This arm was created in response to numerous requests from companies both local and overseas to ITE for providing training and consultancy services. Based on the requirement ITE incorporated a holding company, ITE Holding Pte Ltd on 13 Jan 2003 and a subsidiary under the holding company ITE Education Services Pte Ltd (ITEES) on 20 Jan 2003. This is the business arm of ITE. It is a good business model where there are a number of leading private industry leaders on the board and they provide management guidance and approve policies of ITEES.

The Mission of ITEES is – To extend the brand name of ITE by capitalizing on its knowledge and expertise in vocational Technical Education and Training.

Certified On-the-Job Training Centre (COJTC) Scheme

A number of companies of various types and belonging to various sectors in Singapore have benefited from Institute of Technical Education‘s (ITE) Certified On-the-Job Training Centre (COJTC) Scheme. This scheme, implemented in April 1994, helped companies maximise the potential of their employees and motivate them to firm up skill levels by recognising OJT certificates for entry into relevant Skills Certificate courses. ITE's COJTC scheme has evolved to better accommodate the training needs of companies.

Critical Infocomm Technology Resource Programme (CITREP)

Critical Infocomm Technology Resource Programme (CITREP) is a training incentive programme by IDA (Infocomm Development Authority of Singapore), started to accelerate the development of specialised infocomm skills needed by the infocomm industry and its user organisations. Funding support under CITREP is open to Singapore-registered organisations that sponsor their employees for training in the endorsed courses, and to self-sponsored individuals. CITREP supports up to 70% of the course and examination fees for endorsed training courses.

Microsoft (Singapore) works with different departments of the Singapore Government to create technological solutions develop IT policy and address issues of mutual concern. This includes investing in the Singaporean economy, education system and IT industry, plus a commitment to local research and development. Courses are provided by Microsoft Certified Trainers at Microsoft Certified Technical Education Centres (Microsoft CTECs).

Annexure 2: Draft questionnaire discussed with companies

Section A: Background

1. Company Name, Address, Location:

2. Respondent Background:
   - Name:
   - Designation:

3. Indicate the sector in which the company is operating:
   a) Consumer Electronics b) IT Hardware c) Components (active/passive) d) Strategic Electronics e) Telecom
   Specify further details, if any.

4. Company Turnover for last 3 years (in Rs.cr) (if possible, provide annual report for FY 2007):

FY 2005	FY 2006	FY 2007

5. Indicate projected business targets for FY 2010 and FY 2015:

	FY 2010	FY 2015
Projected revenue target		
Projected growth rate (%)		

6. Main lines of business and share of revenues:

Line of Business	Share of Revenues

Section B: Current and Estimated Manpower Requirements

7. Indicate no. of employees in last 2 years:

FY 2006	FY 2007

8. Indicate function wise employee details for FY 2007:

Major Functions	%. of total employees (approx.)
Purchase, Logistics	
Manufacturing / Core Operations	
Sales	
Service and After-sales support	
Finance	
HR	
Others (top management, etc.)	

9. Indicate number of employees and the functional area (Manufacturing, Sales, Service, Research, Support areas – Finance, HR, etc.) which they are assigned to with the following education qualifications for FY 2007:

Qualification	No. of employees (or %)	Functional Areas Assigned to
Ph. D's /Research		
Engineers (mention specialization)		
BA/BSc/BCom (Arts and Science)		
Diploma Engineers (mention specialization)		
ITI (mention trades)		
12^{th} standard/10^{th} standard/school education		
Below 10^{th} standard		
Others (specify – such as MBAs, CA, ICWA, CS, etc.)		

10. **Productivity:** Please indicate the following pertaining to productivity and the trends expected thereof, if possible.

a) Drivers of productivity –

b) Key trends expected in productivity –

	2010	2012	2015
Productivity (revenue per employee)			

11. Does your company find the requisite number of people? What are the key areas where manpower shortages exist?

Section C: Skill Requirements and Gaps

12. What is (are) the core function(s) of your company? (such as predominantly Manufacturing, Assembly and Sales, only Sales, pure Research/Design - illustrative)

(such as Product Development -> Design -> Testing -> Manufacturing -> Sales -> Service; (or) Component Purchase -> Assembly -> Inspection/QC/QA -> Packaging and Dispatch) – Please elaborate

13. **Functions, levels, skills expected, and skill gaps:** In order to perform the above activities, for the core functions - indicate the profile of people employed at different levels, skill requirements, and the skills gaps thereof?

'Core Functions' would be such as *Manufacturing – Design, Testing, Sales, after-sales service, Research and Development, and so on.*
'Levels' would be such as *Helpers, Operators, Supervisors, Production Manager, and so on, depending on the function.*

Core Function 1 (such as Manufacturing):

#	Level	Profile of people recruited / Qualification	Responsibilities	Skills Expected	Skill Gaps
1					
2					
3					
4					
5					

Core Function 2 (such as Sales):

#	Level	Profile of people recruited / Qualification	Responsibilities	Skills Expected	Skill Gaps
1					
2					
3					
4					
5					

Core Function 3: (Research & Development)

#	Level	Profile of people recruited / Qualification	Responsibilities	Skills Expected	Skill Gaps
1					
2					
3					
4					
5					

14. In which areas do you see a major skill deficiency/shortage (in terms of functional and soft skills) over the next **5-10 years** for various levels of people depending on expected changes in industry dynamics?

Major Areas/Functions where skill gaps would emerge in next 5-10 years:

Major Levels in which such gaps would emerge in next 5-10 years:

What would these skill gaps be in next 5-10 years:

Section D: Education Institute and Curriculum related

15. Indicate your recruitment sources/sources of manpower

Colleges –
Diploma Institutes –
ITI –
Lateral hiring (indicate sources) –

16. Indicate the key issues in the following areas pertaining to various institutes:

	Infrastructure related (capacity of institutes, quality of teaching, etc)	Availability related (whether enough in number, etc.)	New courses to be introduced/modifications required in current ones
Ph.D/Research Institutions			
Engineering colleges			

	Infrastructure related (capacity of institutes, quality of teaching, etc)	Availability related (whether enough in number, etc.)	New courses to be introduced/modifications required in current ones
Diploma/Polytechnics			
ITI			
Other vocational streams			

Section F: Interventions

17. Do you see any issues pertaining to manpower requirements and skill gaps unique to your cluster/region? If so, what are they and what should be done to address them by Government/ industry, educational institutions/ industry associations?

Annexure 3: Entities interacted with as part of the study

Companies:

	Name of Company
1	GSP Electronics Pvt. Ltd.
2	HCL Infosystems Ltd.
3	Moser Baer India Ltd.
4	Motorola India Private Ltd.
5	Salora International Ltd.
6	Samtel Color Ltd.
7	Dixon (Technologies) India
8	Continental Device India Ltd.
9	ST Microelectronics Pvt. Ltd.
10	Kores India
11	Molex (India) Ltd.
12	Wipro e Peripherals
13	Wipro Infotech
14	Bharat Electronics Ltd.
15	Cadence Design Systems
16	Intel Corporation
17	Hewlett Packard
18	Flextronics Technologies
19	Nokia India Pvt. Ltd.
20	Trend Electronics Limited (formerly Videocon Communications Limited)
21	TVS-E Servicetec Limited.
22	Deki Electronics

Government:

We have interacted with representatives of the following Government departments to obtain their inputs on the study:

- Department of Information Technology, Ministry of Communications and Information Technology, Government of India
- Directorate General of Employment and Training, Ministry of Labour, Government of India
- Ministry of Human Resource Development
- National Manufacturing Competitiveness Council.

Annexure 4: Detailing of human resource requirement at various scenarios

This annexure details the human resource requirement under various scenarios discussed as part of the sensitivity analysis. While the 'most likely' scenario has been detailed as a part of the main report, the remaining two possible scenarios are detailed in this section.

Industry size and human resource requirement – for Scenario 1 (15% growth rate in the industry)

This scenario assumes that the growth rates are a continuation of the existing industrial growth rates averaging about 15%.

The following table presents the size of various sectors under the scenario that the IT Hardware and Electronics Manufacturing Industry grows by a CAGR of 15%.

Table 31 : Forecasted size of industry by sector – 2009-15

Size of industry in Rs. cr	2009	2010	2011	2012	2013	2014	2015	CAGR
Electronics and IT Hardware Industry in India	**87,285**	**100,378**	**115,434**	**132,750**	**152,662**	**175,561**	**201,896**	**15%**
Consumer Electronics	24,688	27,429	30,475	33,859	37,618	41,795	46,436	11%
Others (Industrial Electronics)	14,017	16,274	18,893	21,934	25,465	29,564	34,322	16%
Computers	18,215	21,729	25,921	30,922	36,887	44,004	52,493	19%
Telecom Equipment	13,097	15,379	18,057	21,202	24,895	29,231	34,322	17%
Strategic Electronics	6,194	7,267	8,525	10,002	11,735	13,767	16,152	17%
Components	11,073	12,300	13,563	14,830	16,062	17,201	18,171	9%

Source: IMaCS analysis

The forecasted total and incremental human resource requirement till 2015 is detailed in the following table.

Table 32 : Incremental human resource requirement 2007-2015

Forecasted human resource requirement 2007 - 2015	2007	2015	Incremental
Electronics and IT Hardware Industry in India	**779,255**	**1,603,710**	**824,455**
Consumer Electronics	189,394	301,015	111,621

Others (Industrial Electronics)	131,313	208,325	77,012
Computers	161,616	493,865	332,249
Telecom Equipment	97,256	254,779	157,523
Strategic Electronics	56,818	144,620	87,802
Components	142,857	201,106	58,248

Source: IMaCS analysis

The human resource requirements at various functions and at different educational levels are illustrated below.

Table 33: Incremental human resource requirement in different functions across sectors

Incremental human resource requirement in various functions till 2015	R&D	Manufacturing	Sales	Service Support	Administration
Consumer Electronics	4,465	55,811	30,138	15,627	5,581
Others (Industrial Electronics)	2,310	55,757	11,552	3,851	3,543
Computers	9,967	69,772	83,062	136,222	33,225
Telecom Equipment	6,301	47,257	47,257	47,257	9,451
Strategic Electronics	10,536	40,784	7,024	17,912	11,546
Components	9,436	36,347	4,660	3,262	4,543
Total requirement in the Industry	**43,016**	**305,727**	**183,693**	**224,130**	**67,889**
Incremental human resource requirement			**824,455**		

Source: IMaCS analysis

Table 34 : Incremental human resource requirement in different educational qualifications till 2015

Incremental human resource requirement in different educational backgrounds till 2015	Ph.D and Research scholars	Engineers	Diploma and other equally certified skills	ITI and other vocational courses	Other graduates such as B.Sc	MBA/CA/CWA	10th / 12th
Consumer Electronics	3,349	10,046	11,162	8,148	30,138	24,557	24,222
Others (Industrial Electronics)	2,310	30,805	7,701	5,083	2,310	4,236	24,567
Computers	13,290	66,450	83,062	33,225	63,127	19,935	53,160
Telecom Equipment	7,876	63,009	31,505	10,397	23,628	8,664	12,444
Strategic Electronics	5,268	32,487	19,316	8,609	8,872	4,149	9,101
Components	3,239	16,310	7,549	9,331	1,992	1,107	18,721
Total requirement in the Industry	**35,332**	**219,106**	**160,296**	**74,793**	**130,068**	**62,646**	**142,214**
Incremental human resource requirement				**824,455**			

Source: IMaCS analysis

Industry size and human resource requirement – for Scenario 2 (30% growth rate in the industry)

This scenario assumes that extent of value addition that would take place in the Indian IT Hardware and Electronics Manufacturing Industry would be much higher due to *'emerging areas'* (illustrated in the earlier sections) taking off in a significant manner also complemented by growth in existing areas (*a mix of new product expansion as well as increased market penetration*) .

The following table presents the size of various sectors under the scenario that the IT Hardware and Electronics Manufacturing Industry grows by a CAGR of 30%. At this growth rate, the size of the industry in 2015 is expected to be around USD 150 billion.

Table 35 : Forecasted size of industry by sector – 2009-15

Size of industry in Rs. Cr	2009	2010	2011	2012	2013	2014	2015	CAGR
Electronics and IT Hardware Industry in India	**111,540**	**145,002**	**188,503**	**245,053**	**318,569**	**414,140**	**538,382**	**30%**
Consumer Electronics	31,548	39,623	49,765	62,503	78,500	98,593	123,828	26%
Others (Industrial Electronics)	17,913	23,508	30,852	40,490	53,139	69,739	91,525	31%
Computers	23,277	31,389	42,329	57,081	76,975	103,802	139,979	35%
Telecom Equipment	16,737	22,215	29,487	39,139	51,950	68,955	91,525	33%
Strategic Electronics	7,915	10,497	13,922	18,464	24,487	32,476	43,071	33%
Components	14,150	17,768	22,148	27,377	33,518	40,576	48,454	23%

Source: IMaCS analysis

The forecasted total and incremental human resource requirement till 2015 is detailed in the following table.

Table 36 : Incremental human resource requirement 2007-2015

Forecasted human resource requirement 2007 – 2015	2007	2015	Incremental
Electronics and IT Hardware Industry in India	779,255	4,276,515	3,497,260
Consumer Electronics	189,394	802,699	613,305
Others (Industrial Electronics)	131,313	555,528	424,214
Computers	161,616	1,316,960	1,155,344
Telecom Equipment	97,256	679,404	582,148
Strategic Electronics	56,818	385,649	328,830
Components	142,857	536,276	393,419

Source: IMaCS analysis

The human resource requirements at various functions and at different educational levels are illustrated below.

Table 37: Incremental human resource requirement in different functions across sectors

Incremental human resource requirement in various functions till 2015	R&D	Manufacturing	Sales	Service Support	Administration
Consumer Electronics	24,532	306,652	165,592	85,863	30,665
Others (Industrial Electronics)	12,726	307,131	63,632	21,211	19,514
Computers	34,660	242,622	288,836	473,691	115,534
Telecom Equipment	23,286	174,644	174,644	174,644	34,929
Strategic Electronics	39,460	152,742	26,306	67,081	43,241
Components	63,734	245,493	31,474	22,031	30,687
Total requirement in the Industry	**198,398**	**1,429,285**	**750,485**	**844,522**	**274,570**
Incremental human resource requirement			**3,497,260**		

Source: IMaCS analysis

Table 38 : Incremental human resource requirement in different educational qualifications till 2015

Incremental human resource requirement in different educational backgrounds till 2015	Ph.D and Research scholars	Engineers	Diploma and other equally certified skills	ITI and other vocational courses	Other graduates such as B.Sc	MBA/CA/CWA	10th / 12th
Consumer Electronics	18,399	55,197	61,330	44,771	165,592	134,927	133,087
Others (Industrial Electronics)	12,726	169,686	42,421	27,998	12,726	23,332	135,324
Computers	46,214	231,069	288,836	115,534	219,515	69,321	184,855
Telecom Equipment	29,107	232,859	116,430	38,422	87,322	32,018	45,990
Strategic Electronics	19,730	121,667	72,343	32,242	33,228	15,537	34,083
Components	21,874	110,157	50,987	63,026	13,455	7,475	126,445
Total requirement in the Industry	**148,051**	**920,636**	**632,347**	**321,993**	**531,840**	**282,610**	**659,784**
Incremental human resource requirement				**3,497,260**			

Source: IMaCS analysis

End of report

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